The Value Added and Operating Surplus Deflators for Industries: The Right Price Indicators That Should Be Used to Calculate the Real Interest Rates

Itsuo Sakuma (Senshu University, Japan), Kazusuke Tsujimura (Keio University, Japan), and Masako Tsujimura (Rissho University, Japan)

Paper prepared for the 34th IARIW General Conference

Dresden, Germany, August 21-27, 2016

Session 8A: Accounting for Finance in the Economy and the SNA II

Time: Friday, August 26, 2016 [Afternoon]

The Value Added and Operating Surplus Deflators for Industries:
The Right Price Indicators that should be Used to Calculate the Real Interest Rates

Itsuo Sakuma (Senshu University, Japan)
Kazusuke Tsujimura (Keio University, Japan)
Masako Tsujimura (Rissho University, Japan)

Abstract

After the global financial crisis of 2008-2009, the governments of the world are piling up deficits to close the saving-investment gap in the private sector. The governments cannot accumulate deficits endlessly so that they must urgently promote the investments in the private industries. It is obvious that lowering the market rate of interest is one of the best policies to boost the capital investment. The problem is that what inflation rate they have in their mind when the entrepreneurs make investment decisions. Not only the output prices, but also the composition of inputs and their prices differ from one industry to another. Therefore, the value added deflator or even the operating surplus deflator for each industry are better alternative to calculate the real interest rate.

JEL Classification: C43, C67, E31
Keywords: GDP deflator, real interest rate, investment decision

Paper prepared for the 34th IARIW General Conference
Dresden, Germany, August 21-27, 2016
Session 8A: Accounting for Finance in the Economy and the SNA II
Time: Friday, August 26, 2016 [Afternoon]

Contents

1. Introduction

A price index is a measure of the proportionate, or percentage, changes in a set of prices over time; usually it consists of per-unit transaction value of specific product (prices) and some indicator of the proportionate composition of the products (share weight) among the group of products in question. For example, a consumer price index (CPI) measures changes in the prices of goods and services that households consume[1]. In an analogy, so called producer price index (PPI) measures changes in the prices of goods and services that domestic producers produce. However, as IMF (2004) asserts, the producers are at the same time purchasers of goods and services because they consume other producers' outputs as intermediate inputs — materials, components, fuels etc. The value added deflator is a price indicator that takes this two-sidedness of the producers; it is defined as the proportion of the nominal value added to the real value added, which is obtainable by dividing both the output and the intermediate inputs in nominal terms by the appropriate price indices[2]. The remaining problem is that the value added deflator does not take the wage rate and other production factor cost into consideration; in this context, it is desirable to obtain the operating surplus deflator rather than the value added deflator. This paper discusses the issues concerning the measurement of the deflators for both value added and operating surplus for each industry.

Although the SNA 1993 did not mention it, the SNA 2008 discusses value added deflator in paragraphs 14.153 through 14.157; it is defined in the framework of the supply and use tables. The proportion of the domestic total of nominal value added to that of real value added is casually referred to as GDP deflator (paragraph 15.235); not a few

---

[1] ILO (2004), paragraph 1.1.

[2] According to the definition of IMF (2004), PPI includes not only output PPI but also input PPI and value-added PPI.

statistical authorities publish it as a part of GDP statistics. Simple mathematics tells us that, as shown in equation (23), the GDP deflator is the weighted harmonic mean of the value added deflators. However, the meaning of the value added deflator for each industry is far more complicated because the weight for one particular item involves the prices of other items.

In addition to the value added deflator, the SNA 2008 mentions the operating surplus deflator in 14.157. In the framework of the generation of income account, the value added consists of three major components: compensation of employees, taxes/subsidies on production and imports, and gross operating surplus / mixed income. As paragraph 14.155 asserts, calculating compensation of employees in volume terms is possible if enough information is available on wage rates and numbers employed by category of worker. If it is possible, it is an easy task to obtain the deflator for compensation of employees. However, it seems far more difficult to know the taxes less subsidies on production in volume terms. To obtain the deflator for gross operating surplus, we have to overcome this critical problem. Despite all the difficulties, we tentatively obtained the deflator for gross operating surplus / mixed income for the Japanese industries to find out further problems we may encounter in practice.

2. Value Added Deflator

2.1 Definitions

Before going into the empirical evidence, we examine the theoretical meaning of the value added deflators using a highly simplified use table in which one industry produces only one product so that the table reduces to a symmetric input output table as shown in Table 1 in current values. Note that paragraph 5.2 of SNA 2008 basically defines industry as a group of establishments engaged in the same production activity. Let subscripts $i, j = 1, \cdots, \mathrm{n}$ and $k, l = 1, \cdots, \mathrm{n}$ denote inputs and outputs respectively. While X_{ik} denotes intermediate input of i into k; D_i, E_i, M_i and T_i indicate domestic final uses, exports, imports and total domestic output of product i respectively. V_k is the gross value added generated in the production process of output k, which is defined as total domestic output less intermediate inputs; the definition is equivalent to that at producer prices described in the SNA 2008, paragraph 6.78. Although a Chenery-Moses input-output table[3], to which Table 1 resembles to, usually assumes one price for one product, we will assume that the import prices are different from domestic prices following the suggestions by Diewert and Nakamura (2010) and Reinsdorf and Yuskavage (2014) that the former affects the latter. Let p_{di} and p_{mi} be the current prices of domestic and imported products respectively while taking the domestic price of the base period to be unity. We assume that only the domestic products are exported. We further assume that the domestic and imported products are indifferent to the domestic users; and are supplied jointly at a composite price p_i, which is the quantity-weighted average of the domestic and import prices. Therefore, we can rewrite the current nominal values in Table 1 in the constant prices as in Table 2 if p_{di} and p_{mi} are observable:

$$e_i = \frac{E_i}{p_{di}}; \quad m_i = \frac{M_i}{p_{mi}}; \quad t_i = \frac{T_i}{p_{di}}. \tag{1}$$

The input-output balance of product i at current price is as follows:

$$T_i = \sum_{k=1}^{n} X_{ik} + D_i + E_i - M_i. \tag{2}$$

The balance at constant price is as follows:

$$t_i = \sum_{k=1}^{n} x_{ik} + d_i + e_i - m_i. \tag{3}$$

3 See Moses (1955) and Chenery and Clark (1959).

The above assumption tells us that the domestic and imported products are supplied at a price, which is the quantity-weighted average of the domestic and import prices:

$$p_i = \frac{X_{ik}}{x_{ik}} = \frac{D_i}{d_i} = \frac{t_i - e_i}{\sum_{l=1}^{n} x_{il} + d_i} p_{di} + \frac{m_i}{\sum_{l=1}^{n} x_{il} + d_i} p_{mi} . \qquad \text{(for any } k \text{)} \qquad (4)$$

Therefore

$$X_{ik} = \left(\frac{t_i - e_i}{\sum_{l=1}^{n} x_{il} + d_i} p_{di} + \frac{m_i}{\sum_{l=1}^{n} x_{il} + d_i} p_{mi} \right) x_{ik} ; \qquad (5)$$

and

$$D_i = \left(\frac{t_i - e_i}{\sum_{l=1}^{n} x_{il} + d_i} p_{di} + \frac{m_i}{\sum_{l=1}^{n} x_{il} + d_i} p_{mi} \right) d_i . \qquad (6)$$

The input deflator for product k is defined as

$$p_k^{input} = \frac{\sum_{i=1}^{n} X_{ik}}{\sum_{i=1}^{n} x_{ik}} = \frac{\sum_{i=1}^{n} p_i x_{ik}}{\sum_{i=1}^{n} x_{ik}} . \qquad (7)$$

Likewise, the input deflator for all domestic products as a composite commodity is obtainable:

$$p^{input} = \frac{\sum_{k=1}^{n} \sum_{i=1}^{n} X_{ik}}{\sum_{k=1}^{n} \sum_{i=1}^{n} x_{ik}} = \frac{\sum_{k=1}^{n} \sum_{i=1}^{n} p_i x_{ik}}{\sum_{k=1}^{n} \sum_{i=1}^{n} x_{ik}} . \qquad (8)$$

The output deflator for product k is by definition:

$$p_k^{output} = \frac{T_k}{t_k} = p_{dk} . \qquad (9)$$

Furthermore, by assuming $t_k = t_i$ and $T_k = T_i$ where $k = i$, we obtain the output deflator for all domestic products in the following manner:

$$p^{output}=\frac{\sum_{k=1}^{n}T_k}{\sum_{k=1}^{n}t_k}=\frac{\sum_{i=1}^{n}T_i}{\sum_{i=1}^{n}t_i}=\frac{\sum_{i=1}^{n}\left\{p_i\left(\sum_{l=1}^{n}x_{il}+d_i\right)+p_{di}e_i-p_{mi}m_i\right\}}{\sum_{i=1}^{n}\left(\sum_{l=1}^{n}x_{il}+d_i+e_i-m_i\right)}. \tag{10}$$

As we have described already, in this model, gross value added for product k is defined as total domestic output less intermediate inputs:

$$\begin{aligned}V_k&=T_k-\sum_{j=1}^{n}X_{jk}\\&=T_i-\sum_{j=1}^{n}X_{jk}\qquad\text{(where } k=i\text{)}\\&=p_i\left(\sum_{l=1}^{n}x_{il}+d_i\right)+p_{di}e_i-p_{mi}m_i-\sum_{j=1}^{n}p_jx_{jk}\ .\end{aligned} \tag{11}$$

By summing up the above equation over $k=1,\cdots,n$, we have the gross domestic product or GDP at current prices, which is often referred to as nominal GDP:

$$\begin{aligned}V_{GDP}&=\sum_{k=1}^{n}V_k=\sum_{i=1}^{n}T_i-\sum_{k=1}^{n}\sum_{j=1}^{n}X_{jk}\\&=\sum_{i=1}^{n}\left\{p_i\left(\sum_{l=1}^{n}x_{il}+d_i\right)+p_{di}e_i-p_{mi}m_i\right\}-\sum_{k=1}^{n}\sum_{j=1}^{n}p_jx_{jk}\\&=\sum_{i=1}^{n}\left(p_id_i+p_{di}e_i-p_{mi}m_i\right).\end{aligned} \tag{12}$$

The above equation proves that GDP is equivalent to the sum of domestic final uses and exports less imports so that GDP can be obtained either in the production approach by summing up value added or in the expenditure approach using the latter relations. We further define real value added for product k in an analogy to equation (11):

$$\begin{aligned}v_k&=t_k-\sum_{j=1}^{n}x_{jk}\\&=t_i-\sum_{j=1}^{n}x_{jk}\\&=\sum_{l=1}^{n}x_{il}+d_i+e_i-m_i-\sum_{j=1}^{n}x_{jk}\ .\end{aligned} \tag{13}$$

By summing up the above equation over $k=i=1,\cdots,n$, we have GDP at constant prices, which is also known as real GDP:

$$v_{GDP} = \sum_{k=1}^{n} v_k = \sum_{i=1}^{n} t_i - \sum_{k=1}^{n}\sum_{j=1}^{n} x_{jk}$$

$$= \sum_{i=1}^{n}\left(\sum_{l=1}^{n} x_{il} + d_i + e_i - m_i\right) - \sum_{k=1}^{n}\sum_{j=1}^{n} x_{jk}$$

$$= \sum_{i=1}^{n}\left(d_i + e_i - m_i\right). \tag{14}$$

According to the traditional double deflation method[4], the value added deflator for product k is defined as the ratio of nominal value added V_k to real value added v_k:

$$p_{vk} = \frac{V_k}{v_k} = \frac{p_i\left(\sum_{l=1}^{n} x_{il} + d_i\right) + p_{di}e_i - p_{mi}m_i - \sum_{j=1}^{n} p_j x_{jk}}{\sum_{l=1}^{n} x_{il} + d_i + e_i - m_i - \sum_{j=1}^{n} x_{jk}}. \tag{15}$$

Likewise, we define GDP deflator as the ratio of nominal GDP to real GDP:

$$p_{GDP} = \frac{\sum_{k=1}^{n} V_k}{\sum_{k=1}^{n} v_k} = \frac{\sum_{i=1}^{n}\left(p_i d_i + p_{di}e_i - p_{mi}m_i\right)}{\sum_{i=1}^{n}\left(d_i + e_i - m_i\right)}. \tag{16}$$

Therefore, in most cases, the expenditure approach is a more convenient way to get real GDP and the GDP deflator.

2.2 Decompositions

The value added deflator for product k could be decomposed in the following manner from equation (15):

$$p_{vk} = \frac{V_k}{v_k} = \frac{p_i\left(\sum_{l=1}^{n} x_{il} + d_i\right) + p_{di}e_i - p_{mi}m_i - \sum_{j=1}^{n} p_j x_{jk}}{\sum_{l=1}^{n} x_{il} + d_i + e_i - m_i - \sum_{j=1}^{n} x_{jk}}$$

[4] Double deflation method is originally proposed by Fabricant (1940) and sophisticated by Stone (1956).

$$= \frac{p_i\left(\sum_{l=1}^{n} x_{il} + d_i\right) + p_{di}e_i - p_{mi}m_i}{\sum_{l=1}^{n} x_{il} + d_i + e_i - m_i} \times \frac{\sum_{l=1}^{n} x_{il} + d_i + e_i - m_i}{\sum_{l=1}^{n} x_{il} + d_i + e_i - m_i - \sum_{j=1}^{n} x_{jk}}$$

$$- \frac{\sum_{j=1}^{n} p_j x_{jk}}{\sum_{j=1}^{n} x_{jk}} \times \frac{\sum_{j=1}^{n} x_{jk}}{\sum_{l=1}^{n} x_{il} + d_i + e_i - m_i - \sum_{j=1}^{n} x_{jk}}$$

$$= \frac{t_k}{v_k} \times p_k^{output} - \frac{\sum_{j=1}^{n} x_{jk}}{v_k} \times p_k^{input}. \qquad (\text{where } \ i = k) \tag{17}$$

The last line of the above equation shows that the value added deflator for product k can be decomposed into (i) output price effects and (ii) input price effects. Alternatively, we can decompose the value added deflator for product k into three parts. Again from equation (15) by substituting equation (4),

$$p_{vk} = \frac{V_k}{v_k} = \frac{p_i\left(\sum_{l=1}^{n} x_{il} + d_i\right) + p_{di}e_i - p_{mi}m_i - \sum_{j=1}^{n} p_j x_{jk}}{\sum_{l=1}^{n} x_{il} + d_i + e_i - m_i - \sum_{j=1}^{n} x_{jk}}$$

$$= \frac{\left(\frac{t_i - e_i}{\sum_{l=1}^{n} x_{il} + d_i} p_{di} + \frac{m_i}{\sum_{l=1}^{n} x_{il} + d_i} p_{mi}\right)\left(\sum_{l=1}^{n} x_{il} + d_i\right) + p_{di}e_i - p_{mi}m_i}{\sum_{l=1}^{n} x_{il} + d_i + e_i - m_i - \sum_{j=1}^{n} x_{jk}}$$

$$- \frac{\sum_{j=1}^{n}\left(\frac{t_j - e_j}{\sum_{l=1}^{n} x_{jl} + d_j} p_{dj} + \frac{m_j}{\sum_{l=1}^{n} x_{jl} + d_j} p_{mj}\right) x_{jk}}{\sum_{l=1}^{n} x_{il} + d_i + e_i - m_i - \sum_{j=1}^{n} x_{jk}}$$

$$= \frac{p_{di}\left(t_i - e_i\right) + p_{mi}m_i + p_{di}e_i - p_{mi}m_i - \sum_{j=1}^{n}\left(\frac{t_j - e_j}{\sum_{l=1}^{n} x_{jl} + d_j} p_{dj} x_{jk}\right) - \sum_{j=1}^{n}\left(\frac{m_j}{\sum_{l=1}^{n} x_{jl} + d_j} p_{mj} x_{jk}\right)}{\sum_{l=1}^{n} x_{il} + d_i + e_i - m_i - \sum_{j=1}^{n} x_{jk}}$$

$$= \frac{p_{di}t_i - \sum_{j=1}^{n}\left(\frac{t_j - e_j}{\sum_{l=1}^{n} x_{jl} + d_j} p_{dj} x_{jk}\right) - \sum_{j=1}^{n}\left(\frac{m_j}{\sum_{l=1}^{n} x_{jl} + d_j} p_{mj} x_{jk}\right)}{\sum_{l=1}^{n} x_{il} + d_i + e_i - m_i - \sum_{j=1}^{n} x_{jk}}$$

$$= \frac{t_i p_{di}}{\sum_{l=1}^{n} x_{il} + d_i + e_i - m_i - \sum_{j=1}^{n} x_{jk}}$$

$$- \frac{\sum_{j=1}^{n}\left(\frac{t_j - e_j}{\sum_{l=1}^{n} x_{jl} + d_j} x_{jk}\right) p_{dj}}{\sum_{l=1}^{n} x_{il} + d_i + e_i - m_i - \sum_{j=1}^{n} x_{jk}}$$

$$- \frac{\sum_{j=1}^{n}\left(\frac{m_j}{\sum_{l=1}^{n} x_{jl} + d_j} x_{jk}\right) p_{mj}}{\sum_{l=1}^{n} x_{il} + d_i + e_i - m_i - \sum_{j=1}^{n} x_{jk}}. \tag{18}$$

The last line of the above equation tells us that the value added deflator for product k consists of three portions: (i) output price effects, (ii) domestically-produced input price effects, and (iii) imported input price effects. Since

$$\frac{m_j}{\sum_{l=1}^{n} x_{jl} + d_j} x_{jk} \geq 0, \tag{19}$$

we can safely conclude that the effects of import prices on the value added deflator is negative.

Likewise, the GDP deflator (for all the domestic products as a composite commodity) could be decomposed in the following manner from equation (16) by substituting equation (4):

$$p_{GDP}=\frac{\sum_{k=1}^{n}V_k}{\sum_{k=1}^{n}v_k}=\frac{\sum_{i=1}^{n}\left(p_i d_i+p_{di}e_i-p_{mi}m_i\right)}{\sum_{i=1}^{n}\left(d_i+e_i-m_i\right)}$$

$$=\frac{\sum_{i=1}^{n}\left\{\left(\frac{t_i-e_i}{\sum_{l=1}^{n}x_{il}+d_i}p_{di}+\frac{m_i}{\sum_{l=1}^{n}x_{il}+d_i}p_{mi}\right)d_i+p_{di}e_i-p_{mi}m_i\right\}}{\sum_{i=1}^{n}\left(d_i+e_i-m_i\right)}$$

$$=\frac{\sum_{i=1}^{n}\left(\frac{\left(t_i-e_i\right)d_i}{\sum_{l=1}^{n}x_{il}+d_i}+e_i\right)p_{di}}{\sum_{i=1}^{n}\left(d_i+e_i-m_i\right)}+\frac{\sum_{i=1}^{n}\left(\frac{d_i}{\sum_{l=1}^{n}x_{il}+d_i}-1\right)m_i p_{mi}}{\sum_{i=1}^{n}\left(d_i+e_i-m_i\right)}. \qquad (20)$$

In other words, the GDP deflator consists of two portions: (i) that depends on the domestic factors, and (ii) that depends on the import prices. It should be noted that, since

$$\frac{d_i}{\sum_{l=1}^{n}x_{il}+d_i}-1\leq 0, \qquad (21)$$

the effects of import prices are inevitably negative.

Alternatively, we can decompose the GDP deflator into consisting products:

$$p_{GDP}=\frac{\sum_{k=1}^{n}V_k}{\sum_{k=1}^{n}v_k}=\frac{\sum_{i=1}^{n}\left(p_i d_i+p_{di}e_i-p_{mi}m_i\right)}{\sum_{i=1}^{n}\left(d_i+e_i-m_i\right)}$$

$$
= \sum_{i=1}^{n} \left\{ \frac{\sum_{l=1}^{n} x_{il} + d_i + e_i - m_i - \sum_{j=1}^{n} x_{jk}}{\sum_{i=1}^{n} (d_i + e_i - m_i)} \times \frac{p_i \left(\sum_{l=1}^{n} x_{il} + d_i \right) + p_{di} e_i - p_{mi} m_i - \sum_{j=1}^{n} p_j x_{jk}}{\sum_{l=1}^{n} x_{il} + d_i + e_i - m_i - \sum_{j=1}^{n} x_{jk}} \right\}
$$

$$
= \sum_{k=1}^{n} \left(\frac{v_k}{\sum_{k=1}^{n} v_k} \times p_{vk} \right). \tag{22}
$$

It means that the GDP deflator is a constant-price value-added weighted average of the value added deflator of each product. The problem of the above equation is that v_k is not directly observable so that the following equation is more widely used.

$$
p_{GDP} = \frac{\sum_{k=1}^{n} V_k}{\sum_{k=1}^{n} v_k} = \frac{\sum_{i=1}^{n} (p_i d_i + p_{di} e_i - p_{mi} m_i)}{\sum_{i=1}^{n} (d_i + e_i - m_i)}
$$

$$
= \frac{\sum_{i=1}^{n} (p_i d_i + p_{di} e_i - p_{mi} m_i)}{\sum_{i=1}^{n} \left[\left\{ p_i \left(\sum_{l=1}^{n} x_{il} + d_i \right) + p_{di} e_i - p_{mi} m_i - \sum_{j=1}^{n} p_j x_{ji} \right\} \times \frac{\left(\sum_{l=1}^{n} x_{il} + d_i + e_i - m_i - \sum_{j=1}^{n} x_{ji} \right)}{\left\{ p_i \left(\sum_{l=1}^{n} x_{il} + d_i \right) + p_{di} e_i - p_{mi} m_i - \sum_{j=1}^{n} p_j x_{ji} \right\}} \right]}
$$

$$
= \frac{\sum_{k=1}^{n} V_k}{\sum_{k=1}^{n} \left(V_k \times \frac{1}{p_{vk}} \right)} \tag{23}
$$

In other words, the GDP deflator is simply regarded as a weighted harmonic mean of the value added deflators.

3. Operating Surplus Deflator

According to paragraphs 1.17 and 7.5 through 7.9 of SNA 2008, there are two main types of charges that producers have to meet out of gross value added: compensation of employees payable to workers employed and any taxes payable less subsidies receivable in the production process. Compensation of employees is defined as the total remuneration payable by an enterprise to an employee in return for work done by the latter. Taxes less subsidies on production consist of taxes payable or subsidies receivable (if negative) on goods or services produced as outputs, and other taxes or subsidies (if negative) on production. After deducting compensation of employees and taxes, less subsidies, on production from value added, the balancing item is obtained. The balancing item is described as gross operating surplus except for unincorporated enterprises owned by households in which the owner or members of the same household may contribute unpaid labor inputs of a similar kind to those that could be provided by paid employees. In the latter case, the balancing item is described as mixed income because it implicitly contains an element of remuneration for work done by the owner, or other members of the household, that cannot be separately identified from the return to the owner as entrepreneur.

As we have mentioned above, operating surplus O_k that includes mixed income is defined by subtracting compensation of employees L_k and taxes (less subsidies) on production, which consists of taxes on products A_k and other taxes on production B_k, from the value added of the industry V_k:

$$O_k = V_k - L_k - A_k - B_k . \qquad (24)$$

As paragraph 14.155 of SNA 2008 asserts, calculating compensation of employees in volume terms is possible if enough information is available on wage rates. Let us assume for simplicity that we can observe the wage rate for each industry w_k taking that of the base period as unity so that we will have the labor input at the constant price:

$$l_k = \frac{L_k}{w_k} . \qquad (25)$$

As United Nations (1979) remarks, there are two types of taxes on production: *ad valorem* and *non ad valorem*; the former is levied as a percentage of the value of goods or services, but the latter is not[5]. Since, in many countries, value-added type tax accounts most of the taxes on products, it must be plausible to define the price of it in reference to the real value added:

$$p_{ak}^{*} = \frac{A_k}{v_k}. \tag{26}$$

We assume here, as a first approximation, that the other taxes on production relate to the output rather than the value added so that we tentatively define its price as:

$$p_{bk}^{*} = \frac{B_k}{t_k}. \tag{27}$$

We will normalize p_{ak}^{*} and p_{bk}^{*} taking those at base period as unity to obtain the taxes-on-products and other-taxes-on-production deflators p_{ak} and p_{bk} so that we can define the taxes at constant prices as follows:

$$a_k = \frac{A_k}{p_{ak}} \text{ and } b_k = \frac{B_k}{p_{bk}}. \tag{28}$$

We further define operating surplus at constant prices in the following manner:

$$o_k = v_k - l_k - a_k - b_k. \tag{29}$$

The operating surplus deflator is defined as follows in analogy to the value added deflator:

$$p_{ok} = \frac{O_k}{o_k}. \tag{30}$$

4. Estimation of the Deflators Using Japanese SNA Data

4.1 Value Added and Operating Surplus Deflators

We will use so-called SNA-IO, the input-output table published as the part of

[5] The decomposition procedure for taxes and subsidies on production is discussed in detail in paragraphs 9.1 through 9.11 of United Nations (1979).

Japanese SNA, to experimentally estimate both value added and operating surplus deflators. The SNA-IO, is an input-output table that consists of the same number of products and corresponding industries[6]. Note that the Input-Output Table for Japan, on which SNA-IO is constructed, is based on the concept of cost accounting so that each column represents the production activity of the corresponding product except for the case of joint production such as oil refinery. Although more detailed table that consists of 87 products is also available, the SNA-IO table we use is a smaller version that consists of 24 products; there is no jointly produced products at this level of aggregation. They also publish the output deflator for each product. Since import prices are not available in the framework, we used the price indices published by the Bank of Japan. We adjusted the import price indices using the international comparative price level data published by OECD[7] so that the domestic price of the product at the base year is unity. Since import price index is not available for services, we simply used the exchange rate as a proxy. In the SNA-IO, the gross value added consists of three portions: compensation of employees, taxes of production (less subsidiaries), and the operating surplus (and mixed income). Since wage deflators are unavailable in the SNA, we used the data published by the Research Institute for Advancement of Living Standards, which is the only Paasche wage index available in Japan. We made the deflator for taxes on production in the procedure described in the previous section. Since the original data of taxes on production included both taxes on products and other taxes on production, we divided it proportionally using the data published for the total economy. The observation period is from 2001 to 2013

[6] Unlike in other countries, in Japan, the use table is made using the SNA-IO and the supply table using the procedure detailed in paragraph 3.83 of SNA 1968 manual, i.e. $\mathbf{B} = \mathbf{AC}$ and $\mathbf{U} = \mathbf{B}\hat{\mathbf{g}}$. See Watanabe (2002) for further details.

[7] OECD (2016), Price Level Indices (indicator). doi: 10.1787/c0266784-en (Accessed on 25 June 2016).

calendar year.

Figures 1-1 through 1-24 depict the fluctuations in the deflators for total outputs, intermediate inputs, and value added for each industry. The correlation coefficients between the deflators are listed in Table 3. The main findings from the figures and the table can be summarized as follows:

(i) The fluctuation patterns of the three deflators vary in one industry from another; there is no general trend. The observation tells us that industry specific value added deflators should be used to calculate real interest rates, which is supposed to be used for the investment decisions.

(ii) It is apparent that the deflators for the value added are more volatile than that for outputs and inputs because the former are the combination of the latter.

(iii) The value added deflators have higher correlation with output deflators rather than with input deflators. The correlation coefficients with output deflators are statistically significant at 5 percent level in 20 out of 24 industries and all of them are positive as expected. In contrast to this, the correlation coefficients with input deflators are statistically significant only in 10 industries, among which only two are negative as expected.

Figure 2 illustrates the fluctuations in the deflators for GDP, total outputs and intermediate inputs across all the industries. While output and input deflators peaked at 2008, the GDP deflator gradually declined during the observation period. It should be noted that, while the correlation coefficient between GDP and total output deflators is positive but not statistically significant, that between GDP and input deflators is not only negative as expected but also statistically significant at 5 percent level[8].

Figures 3-1 through 3-24 illustrate the fluctuations in the value-added and operating surplus deflators during the observation period. Figures 4-1 through 4-24 depict the fluctuations in the wage rate and the deflators for taxes on products, other taxes on production, of each industry. The correlation coefficients between the deflators are listed in Table 4. The main findings from the figures and the table are summarized as follows:

(iv) Although there is no general fluctuation pattern among the industries, the operating surplus deflators fluctuate more widely not only than the valued added deflators but also than any other deflators. Negative deflator is observed in seven out of 24 industries because operating surplus at constant price is negative.

(v) Even though the levels are different, the value added and operating surplus deflators are highly correlated in most of the industries. The correlation coefficients are positive and statistically significant at 5 percent level in 17 out of 24 industries; the coefficients exceed 0.9 in nine industries.

(vi) Generally speaking, the wage rates declined in the manufacturing industries while increased in the non-manufacturing industries during the observation period.

(vii) The two tax deflators are positively correlated in 21 out of 24 industries; among which, the correlation coefficients are statistically significant at 5 percent level in 15 industries.

(viii) The operating surplus deflators tend to have relatively higher correlations with output and input deflators rather than with wage rates and the tax deflators.

[8] There is an apparent contradiction between the micro and macroscopic findings; this comes from the difference in the industrial composition between the nominal input and output.

Figure 5 illustrates the fluctuations in the deflators for operating surplus, wage rate and the tax deflators, for taxes on products and other taxes on production, across all the industries. While other three indicators are somewhat fluctuating during the observation period, the operating surplus deflator declined significantly. There is a high correlation between the value added and operating surplus deflators; the correlation coefficient is as high as 0.965. There is a negative and significant correlation between the input and operating surplus deflators. Although the operating surplus deflator is significantly correlated neither with the wage rate nor taxes-on-products deflator, we do not know why, but we found a significant positive correlation with the other-taxes-on-production deflator.

4.2 Decomposition of the Value Added Deflators

Figure 6 depicts the decomposition of the value added deflator for each industry for 2013 in terms of equation (18) above. The blue line that lies above zero suggests that the output price effect surpasses the input price effect in any of the 24 industries listed there. Although, the import prices forms the larger part of the input price effect in ‘petroleum and coal products’ and ‘electricity, gas and water supply’ industries, the domestic prices account for more than half in most of the industries. The ratio of the output price effects to the input price effects is larger in the service industries comparing to the other industries. The ratio is smaller in the industries that heavily depend on imports.

Although the trend is reversed after 2012, as shown in Figure 7, the GDP deflator gradually declined during the observation period. The decomposition of equation (22), which is illustrated in Figure 8, tells us that only ‘transportation and communication’ significantly affected positively on the deflator. It should be noted however, this is not because the value added deflator of the industry rose, but because the production share of the industry increased considerably. In contrast to this, although the value added deflators for ‘mining’, ‘foods and beverages’ and ‘textiles’ increased as shown in Figure 1, these industries affected negatively on the overall GDP deflator. Figure 7 also depicts the decomposition of GDP deflator into domestic and import deflator effects. As equation (20) suggests, while domestic output deflator affects positively on the GDP deflator, import prices give negative effects on the deflator. Figure 7 clearly illustrates that the decline in Japanese GDP deflator during the observation period originated in the increase in the import prices. Furthermore, the decomposition in Figure 9, which is also based on equation (20), suggests that both quantity and price increase in the import of mining products, such as oil and ore, caused the decline in the GDP deflator.

5. Concluding Remarks

Wicksell (1898; Chapters VIII and IX) defined natural rate of interest (natürliche Kapitalzins) as the physical rate of return on capital investment at the time. If the market rate of interest on loans (Darlehnszins) is below the natural rate, entrepreneurs will borrow funds and make profit by investing in capital goods. On the contrary, if the market rate is above the natural rate, the entrepreneurs will be hesitant to borrow so that capital investment will stagnate. However, Wicksell also asserted that, even in such a situation, the entrepreneurs are willing to invest if they face an inflation because it will increase the monetary return. Therefore, he concluded that capital investment will increase as the real rate of interest, which is market rate of interest less rate of inflation, declines. The problem is that what inflation rate they have in their mind when the entrepreneurs make investment decisions. Customarily, overall nationwide CPI or output PPI, which are the broad and general indices of the output prices that the producers get, is used for this purpose[9]. The shortcoming is that this practice overlooks the fact that the producers are at the same time purchasers of goods and services because they consume other producers' outputs as intermediate inputs. Not only the input and output prices, but also the composition of inputs dramatically differ from one industry to another. Therefore, the value added deflator or even the operating surplus deflator for each industry are better alternative to calculate the real interest rate. Theoretically speaking, operating surplus deflator is the better option because it is the producer's profit after paying wages and taxes. However, our experimental attempt shows that the observed operating surplus deflators are often volatile and tend to be negative. Since our experiments also suggests, in most cases, the operating surplus deflator is highly correlated with the value added deflator so that we should not bother to obtain the former.

After the global financial crisis of 2008-2009, public debt in advanced economies has increased substantially. High levels of public debt in mature economies are a relatively new global concern, after decades of attention on debt levels in developing and emerging countries. With slowly growing or declining workforces, as well as high capital-labor ratios, many advanced economies face an apparent dearth of domestic investment opportunities, while the ageing society calls for more savings to prepare for the retirement. The governments are piling up deficits to close the saving-investment gap in the private sector. It is apparent however that the governments cannot accumulate deficits endlessly so that they must urgently promote the investments in the private industries. According to the Wicksell's framework, it is obvious that lowering the market rate of interest is one of the best policies to boost the capital investment. The problem is that Figure 6, which

[9] See European Central Bank (1999) for further discussion.

is the GDP deflator decomposition based on equation (20), asserts that import price hike would inevitably depress the GDP deflator, the general indicator of the value added deflators. Equation (18) also confirms that the increase in import prices will affect negatively on the value added deflators. It means that if lowering interest rate induces unfavorable rate of exchange (i.e. depreciation of own currency) it will depress value added deflators, and in turn, will depress capital investments. In this sense, lowering interest rate is a double-edged sword; the governments and central banks should think twice before taking such a policy.

References

Chenery, Hollis Burnley and Paul G. Clark (1959) *Interindustry Economics*, New York: John Wiley & Sons.

Diewert, Walter Erwin and Alice O. Nakamura (2010) "Bias Due to Input Source Substitutions: Can It Be Measured?" in Susan Houseman and Kenneth Ryder (eds.) *Measurement Issues Arising from the Growth of Globalization*, Washington D.C.: National Academy of Public Administration, pp. 237-265.

European Central Bank (1999) "Key Issues for the Analysis of Real Interest Rates in the Euro Area," *ECB Monthly Bulletin*, March 1999, 16-18.

Fabricant, Solomon (1940) *The Output of Manufacturing Industries, 1899-1937,* New York: National Bureau of Economic Research.

International Labour Organization et al. (2004) *Consumer Price Index Manual: Theory and Practice*.

International Monetary Fund Statistics Department (2004) *Producer Price Index Manual*:

Theory and Practice.

Moses, Leon Nathan (1955) “The Stability of Interregional Trading Patterns and Input-Output Analysis,” *American Economic Review*, 45(5), pp. 803-826.

Reinsdorf, Marshall and Robert Yuskavage (2014) “Offshoring, Sourcing Substitution Bias and Measurement of U.S. Import Prices, GDP and Productivity,” UTokyo Price Project Working Paper Series 41.

Stone, Richard (1956) *Quantity and Price Indexes in National Accounts*, Paris: Organisation for European Economic Co-operation.

United Nations (1979) *Manual on National Accounts at Constant Prices*, Series M, Number 64.

Watanabe, Genjiro (2002) “SNA 産業連関表の特徴と活かし方” (The Features and Applications of the SNA Input-Output Account; in Japanese), 季刊国民経済計算 (*National Accounts Quarterly*), 128.

Wicksell, Knut (1898) *Geldzins und Güterpreise: eine Studie über die den Tauschwert des Geldes bestimmenden Ursachen*, Jena: Gustav Fischer; translated by Richard Ferdinand Kahn in 1936 as *Interest and Prices: a Study of the Causes Regulating the Value of Money*, London: Macmillan.

Table 1: Symmetric use table at current prices

		Industries (Production Activities)					Domestic Final Uses	Exports	Imports	Total Domestic Output
		1	$\cdots$	k	$\cdots$	n				
Products	1	X_{11}	$\cdots$	X_{1k}	$\cdots$	X_{1n}	D_1	E_1	$-M_1$	T_1
	$\vdots$	$\vdots$	$\ddots$	$\vdots$	$\iddots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	i	X_{i1}	$\cdots$	X_{ik}	$\cdots$	X_{in}	D_i	E_i	$-M_i$	T_i
	$\vdots$	$\vdots$	$\iddots$	$\vdots$	$\ddots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	n	X_{n1}	$\cdots$	X_{nk}	$\cdots$	X_{nn}	D_n	E_n	$-M_n$	T_n
Value	Added	V_1	$\cdots$	V_k	$\cdots$	V_n				
Total	Output	T_1	$\cdots$	T_k	$\cdots$	T_n				

Table 2: Symmetric use table at constant prices

		Industries (Production Activities)					Domestic Final Uses	Exports	Imports	Total Domestic Output
		1	$\cdots$	k	$\cdots$	n				
Products	1	$p_1 x_{11}$	$\cdots$	$p_1 x_{1k}$	$\cdots$	$p_1 x_{1n}$	$p_1 d_1$	$p_{d1} e_1$	$-p_{m1} m_1$	$p_{d1} t_1$
	$\vdots$	$\vdots$	$\ddots$	$\vdots$	$\iddots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	i	$p_i x_{i1}$	$\cdots$	$p_i x_{ik}$	$\cdots$	$p_i x_{in}$	$p_i d_i$	$p_{di} e_i$	$-p_{mi} m_i$	$p_{di} t_i$
	$\vdots$	$\vdots$	$\iddots$	$\vdots$	$\ddots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	n	$p_n x_{n1}$	$\cdots$	$p_n x_{nk}$	$\cdots$	$p_n x_{nn}$	$p_n d_n$	$p_{dn} e_n$	$-p_{mn} m_n$	$p_{dn} t_n$
Value	Added	$p_{v1} v_1$	$\cdots$	$p_{vk} v_k$	$\cdots$	$p_{vn} v_n$				
Total	Output	$p_{d1} t_1$	$\cdots$	$p_{dk} t_k$	$\cdots$	$p_{dn} t_n$				

Table 3: Correlation coefficients between value added and related deflators (2001-2013)

		Correlation coefficients between total output and value added deflators	Correlation coefficients between input and value added deflators
1	Agriculture, forestry and fishing	0.5985	-0.4283
2	Mining	0.9184	0.3651
3	Foods and beverages	0.8349	0.3694
4	Textiles	0.8782	0.5113
5	Pulp and paper products	0.9725	0.7801
6	Chemical products	0.9677	0.9233
7	Petroleum and coal products	0.6609	0.5523
8	Quarrying and pottery	-0.1160	-0.7554
9	Primary metals	0.9543	0.9268
10	Fabricated metal products	-0.0940	-0.3182
11	General machinery	0.6206	-0.5184
12	Electric machinery and equipment	0.9691	0.9067
13	Transportation equipment	0.6300	-0.0716
14	Precision equipment	0.8009	0.5411
15	Miscellaneous manufacturing	0.3911	-0.1290
16	Construction	0.8914	0.6283
17	Electricity, gas and water supply	-0.2352	-0.8261
18	Wholesale and retail trade	0.9715	0.4745
19	Finance and insurance	0.9991	0.9124
20	Real estate	0.9940	0.8584
21	Transportation and communication	0.9785	0.0622
22	Services	0.9453	-0.1221
23	Services provided by Government	0.9900	0.2777
24	Services provided by NPISH	0.9967	0.5653
	Total	0.4659	-0.6038

Table 4: Correlation coefficients between operating surplus and related deflators (2000-2013)

	Correlation coefficients between	total output and operating surplus deflators	input and operating surplus deflators	value added and operating surplus deflators	wage rate and operating surplus deflator	taxes-on-products and operating surplus deflators	other-taxes-on-production and operating surplus deflators	taxes-on-products and other-taxes-on-production deflators
1	Agriculture, forestry and fishing	0.2298	-0.5787	0.7655	-0.6388	-0.0181	0.1000	0.9838
2	Mining	-0.3749	-0.1356	-0.4122	-0.5412	-0.1974	-0.0598	0.8721
3	Foods and beverages	0.8340	0.4252	0.9542	-0.8081	0.1327	-0.3098	0.4888
4	Textiles	-0.7021	-0.7007	-0.5116	0.3518	0.1591	-0.0682	0.8076
5	Pulp and paper products	0.9330	0.7831	0.9506	-0.5271	0.5515	0.1445	0.6345
6	Chemical products	0.9814	0.9574	0.9775	-0.0980	0.6886	-0.9262	-0.8092
7	Petroleum and coal products	0.0163	-0.0177	0.1711	-0.4783	-0.2889	-0.0340	0.4457
8	Quarrying and pottery	-0.1336	-0.7167	0.9595	0.5884	0.0476	-0.1166	0.4432
9	Primary metals	0.4914	0.4516	0.6706	-0.1456	0.1882	-0.4263	0.4399
10	Fabricated metal products	0.2298	0.1085	0.4617	0.1472	-0.2485	-0.2114	0.5757
11	General machinery	0.4712	-0.3671	0.7525	-0.0695	-0.1006	0.3922	0.3470
12	Electric machinery and equipment	-0.2971	-0.2394	-0.2786	-0.1264	0.3204	0.2644	0.7112
13	Transportation equipment	0.3693	-0.2863	0.8745	-0.4187	0.0499	0.7496	-0.0769
14	Precision equipment	0.8260	0.6163	0.9319	-0.3919	-0.2510	-0.3223	0.3341
15	Miscellaneous manufacturing	-0.1513	-0.0206	-0.2293	-0.3577	0.3724	0.3336	0.8602
16	Construction	-0.6912	-0.5828	-0.6726	0.3502	-0.0309	-0.2411	0.9283
17	Electricity, gas and water supply	0.0669	-0.6102	0.9444	0.3037	-0.2746	0.5195	-0.7973
18	Wholesale and retail trade	0.4128	-0.3342	0.5978	-0.7601	0.5866	0.2222	0.6599
19	Finance and insurance	0.9879	0.8838	0.9908	-0.0370	0.0326	0.0449	0.9989
20	Real estate	0.9855	0.8328	0.9960	0.7675	0.8613	0.7258	0.8795
21	Transportation and communication	0.9642	0.0844	0.9807	0.7968	0.7262	0.8884	0.9205
22	Services	0.8492	0.0309	0.8489	-0.8025	0.5066	0.2336	0.8658
23	Services provided by Government	0.8966	0.0986	0.9273	0.6738	-0.9254	-0.8375	0.9071
24	Services provided by NPISH	0.8748	0.5060	0.8769	-0.0374	-0.0254	0.1618	0.8824
	Total	0.3155	-0.7045	0.9654	0.3999	0.0311	0.8473	0.3228

Figure 1: The fluctuations in the deflators for total outputs, intermediate inputs and value added

Figure 1-1: Agriculture, forestry and fishing

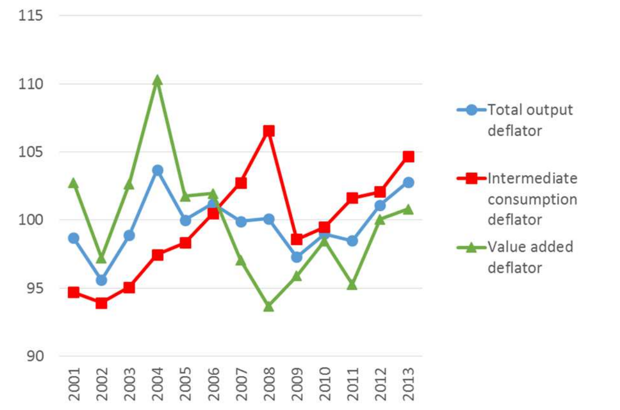

Figure 1-2: Mining

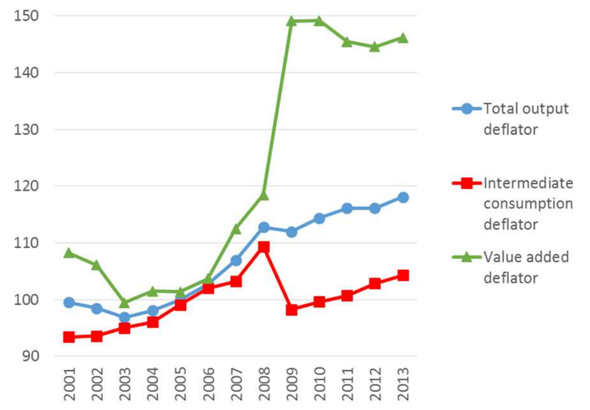

Figure 1-3: Foods and beverages

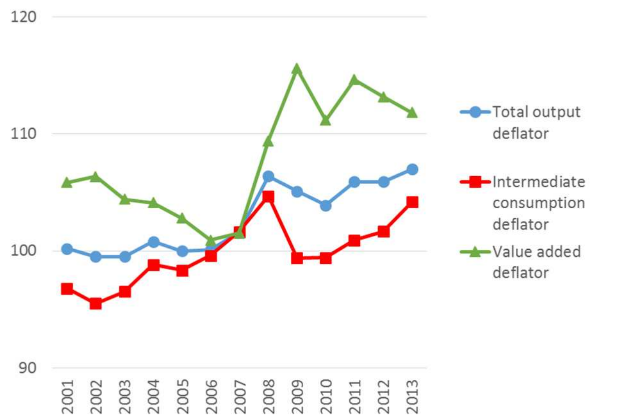

Figure 1-4: Textiles

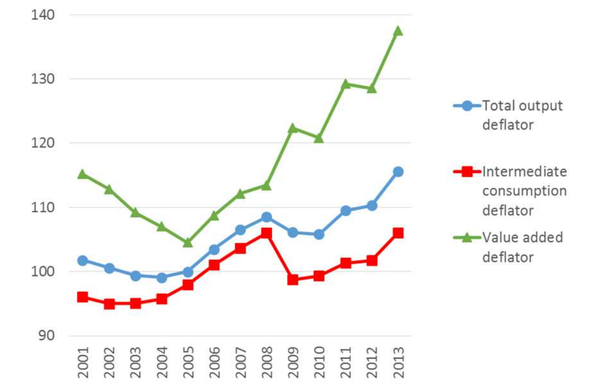

Figure 1-5: Pulp and paper products

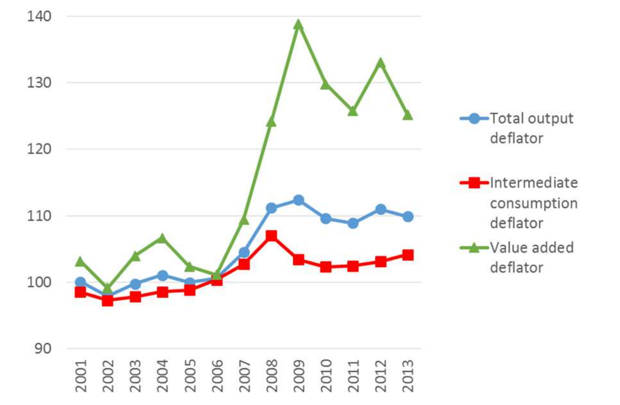

Figure 1-6: Chemical products

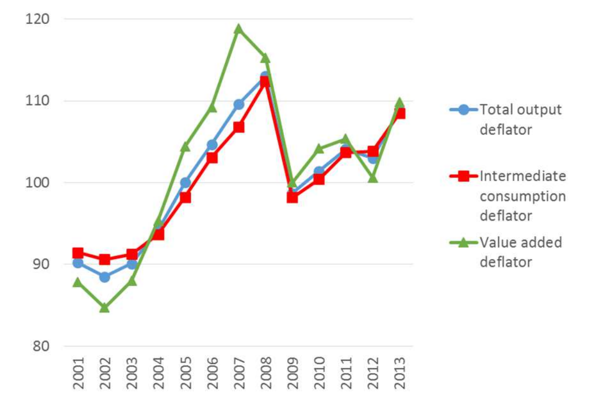

Figure 1-7: Petroleum and coal products

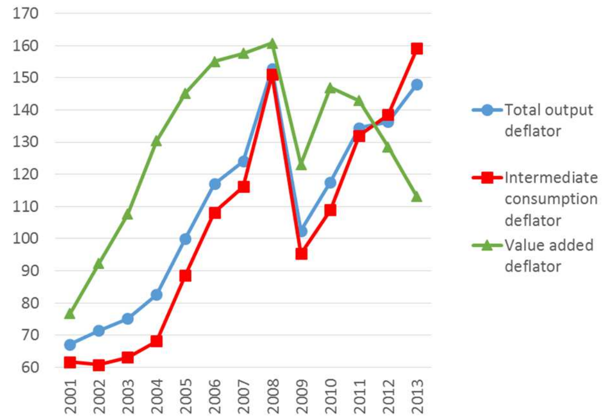

Figure 1-8: Quarrying and pottery

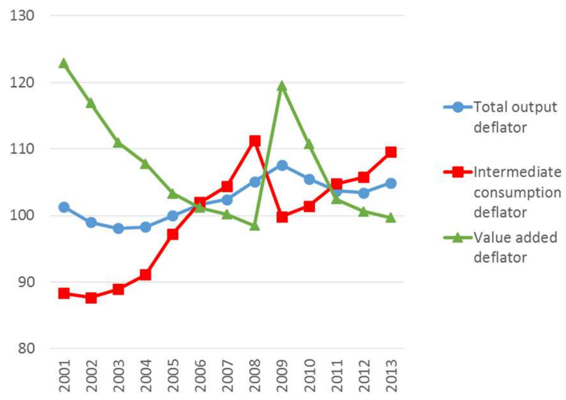

Figure 1-9: Primary metals

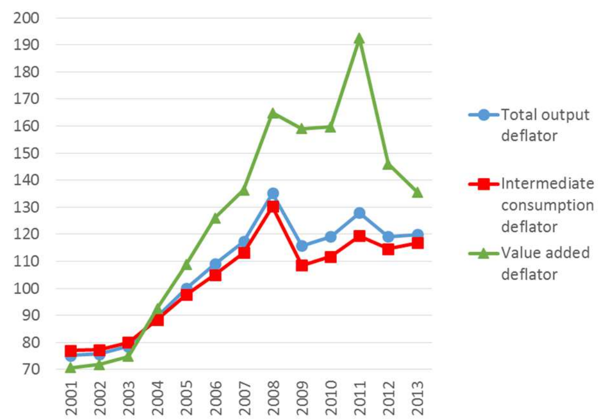

Figure 1-10: Fabricated metal products

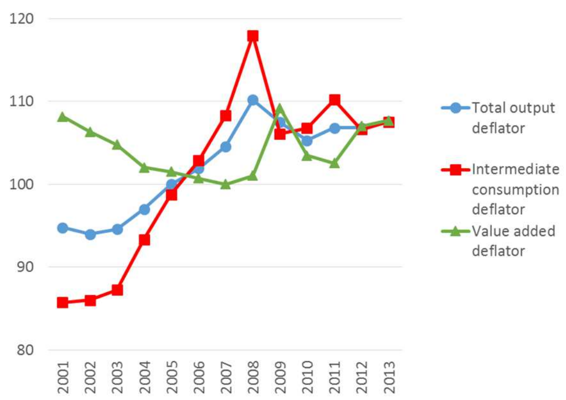

Figure 1-11: General machinery

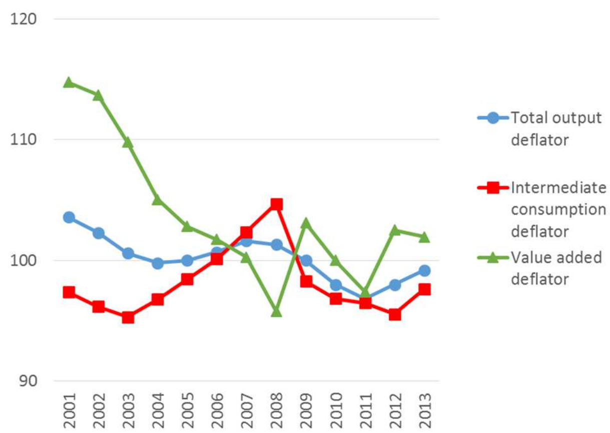

Figure 1-12: Electric machinery and equipment

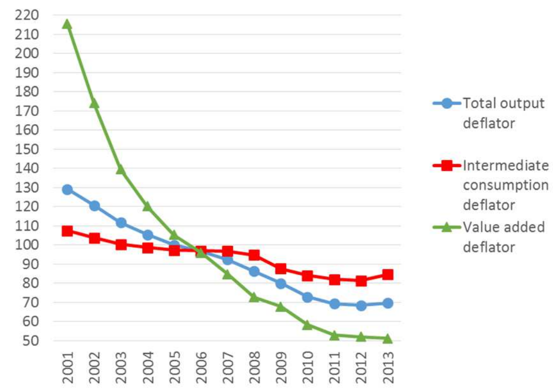

Figure 1-13: Transportation equipment

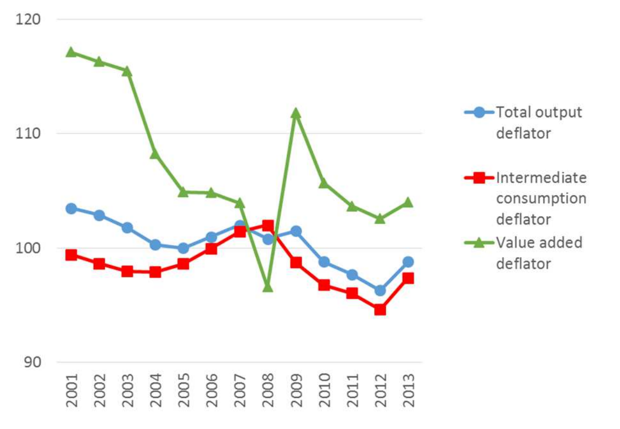

Figure 1-14: Precision equipment

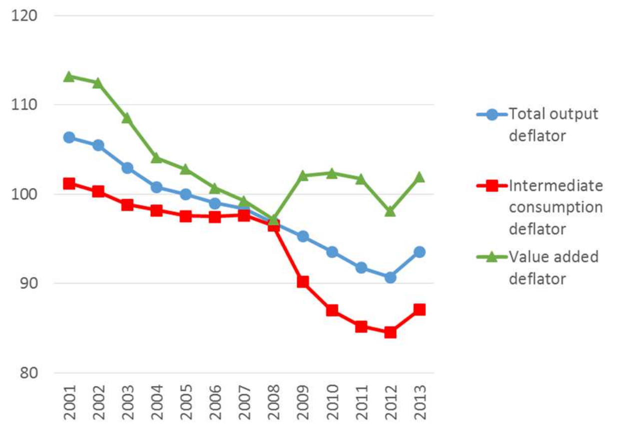

Figure 1-15: Miscellaneous manufacturing

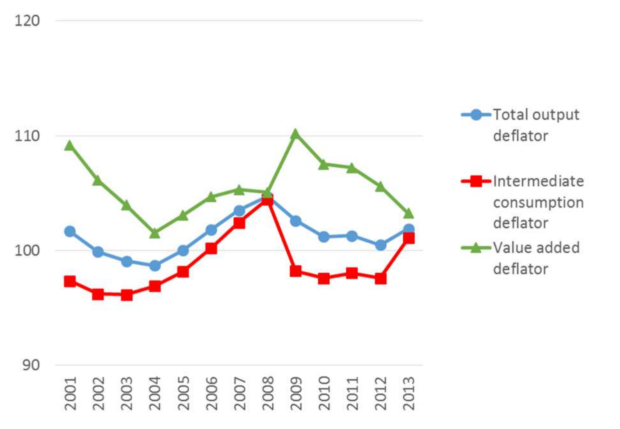

Figure 1-16: Construction

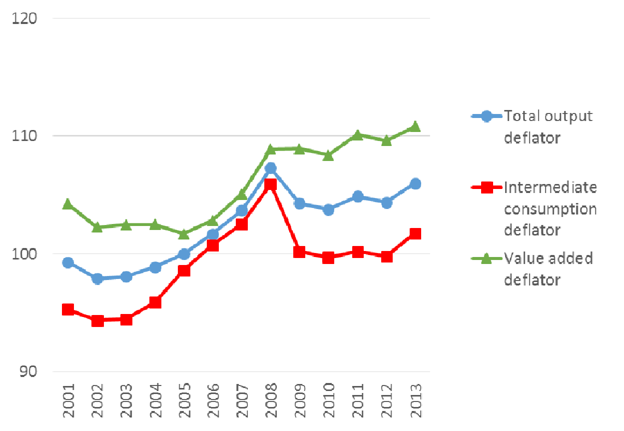

Figure 1-17: Electricity, gas and water supply

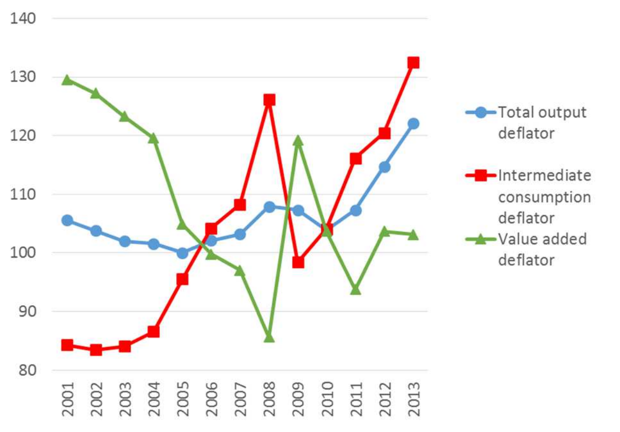

Figure 1-18: Wholesale and retail trade

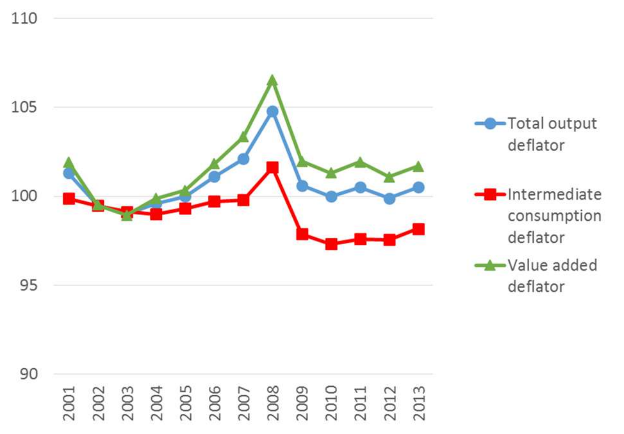

Figure 1-19: Finance and insurance

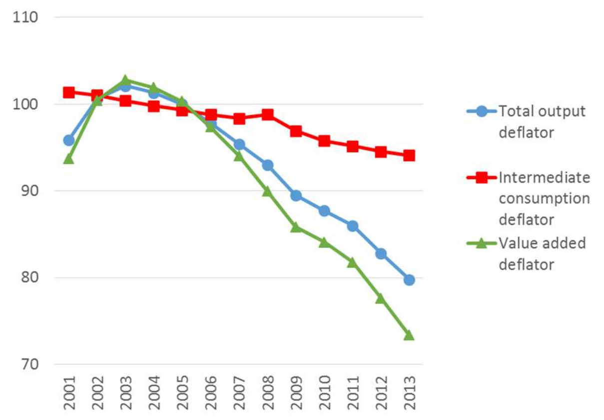

Figure 1-20: Real estate

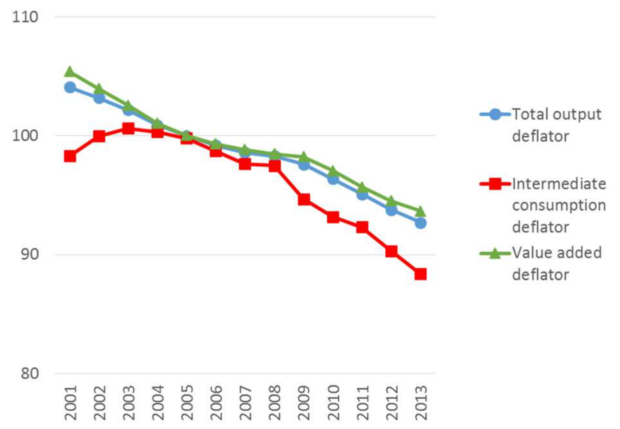

Figure 1-21: Transportation and communication

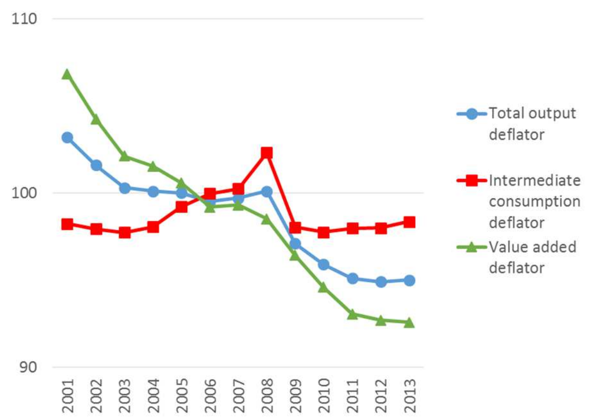

Figure 1-22: Services

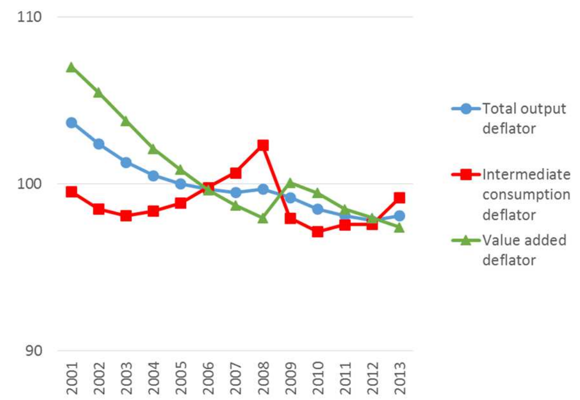

Figure 1-23: Services provided by Government

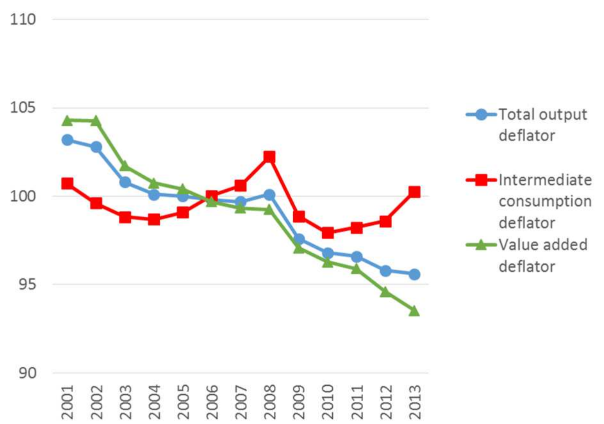

Figure 1-24: Services provided by NPISH

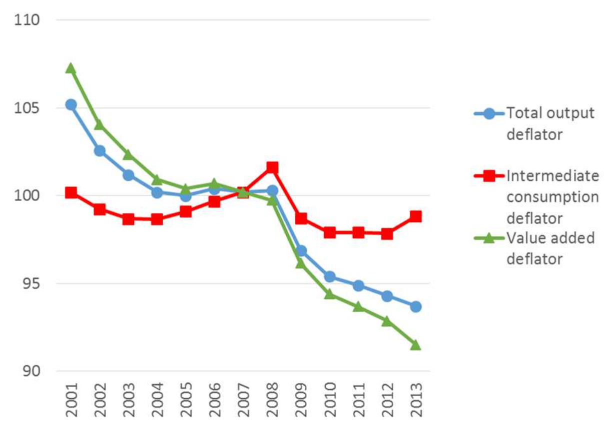

Figure 2: The fluctuations in the deflators for GDP, total outputs and inputs across all the sectors

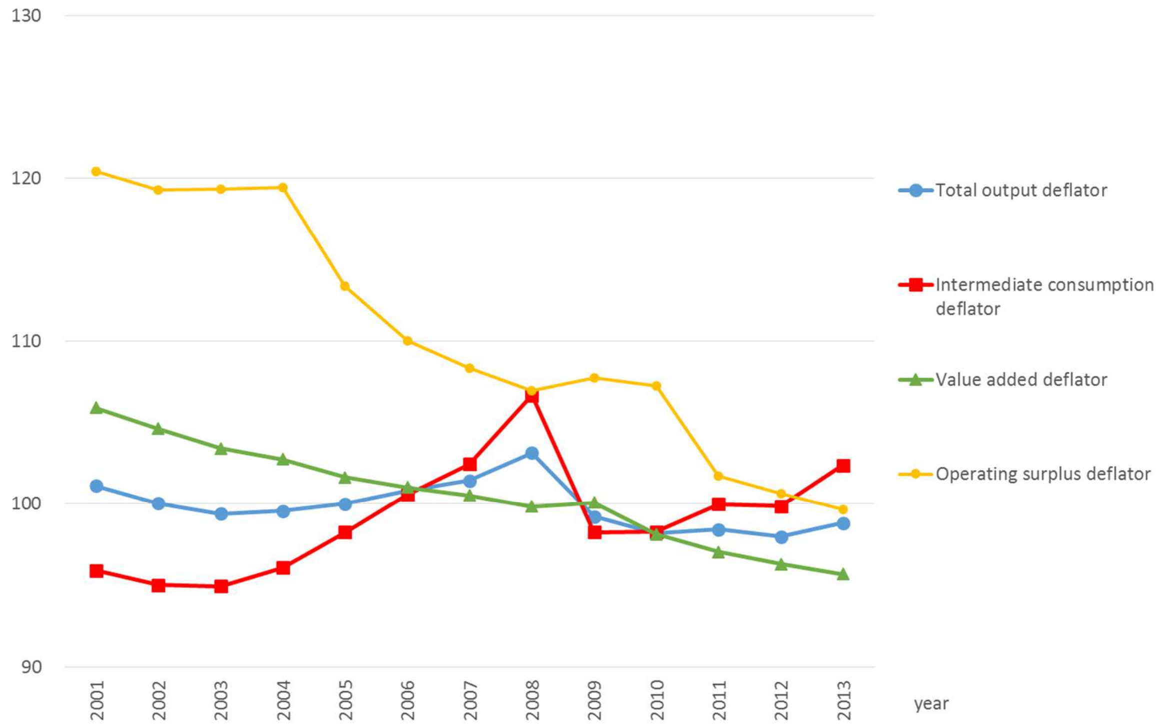

Figure 3: The fluctuations in the value added and operating surplus deflators

Figure 3-1: Agriculture, forestry and fishing

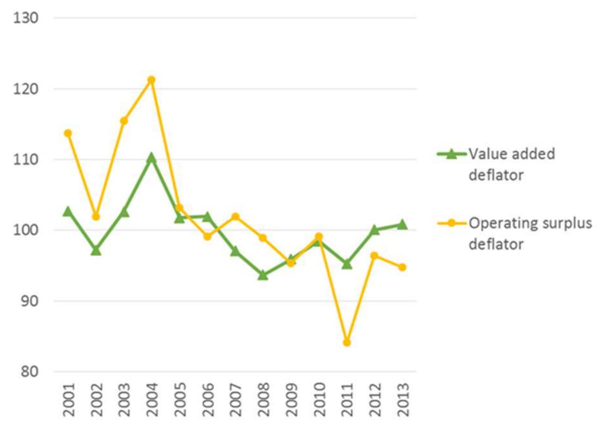

Figure 3-2: Mining

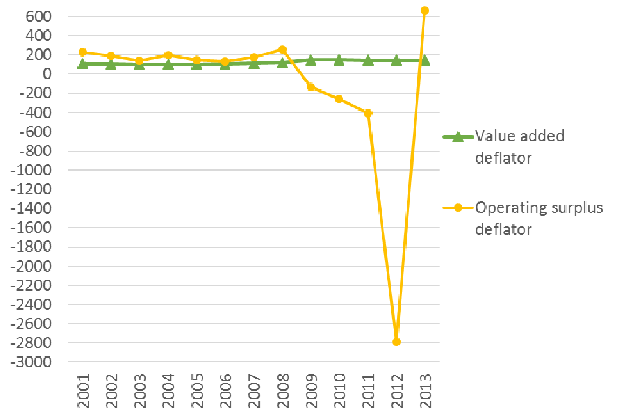

Figure 3-3: Foods and beverages

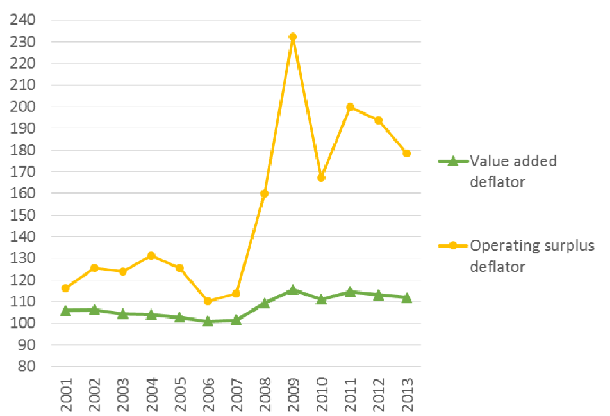

Figure 3-4: Textiles

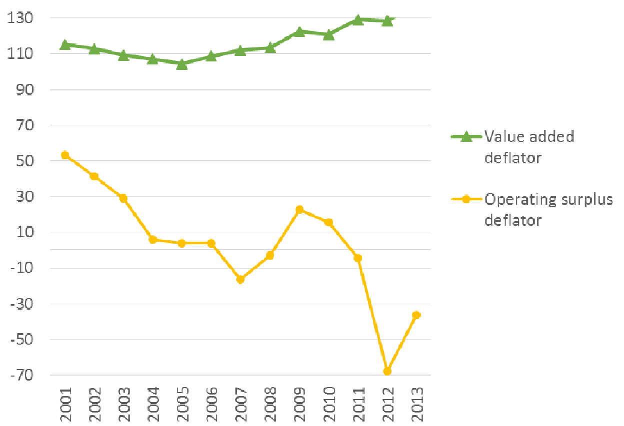

Figure 3-5: Pulp and paper products

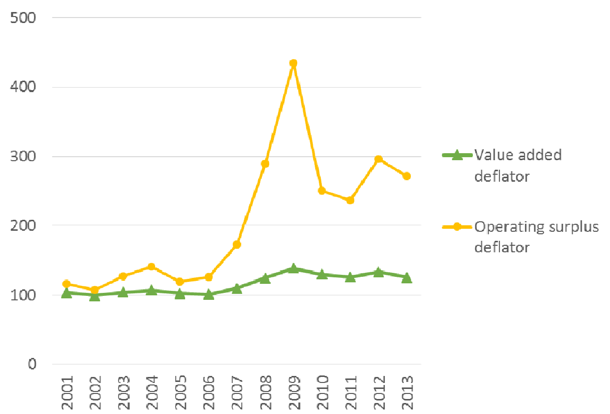

Figure 3-6: Chemical products

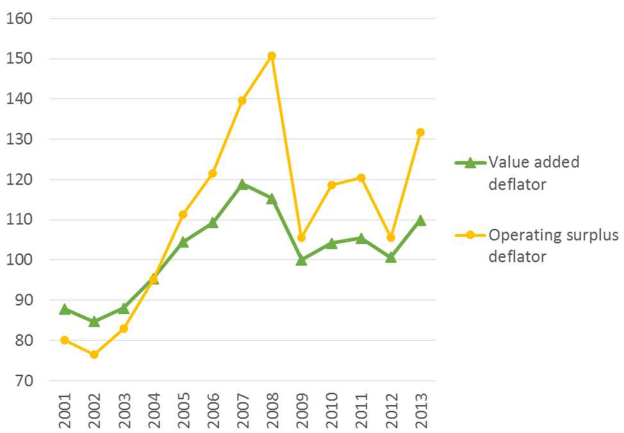

Figure 3-7: Petroleum and coal products

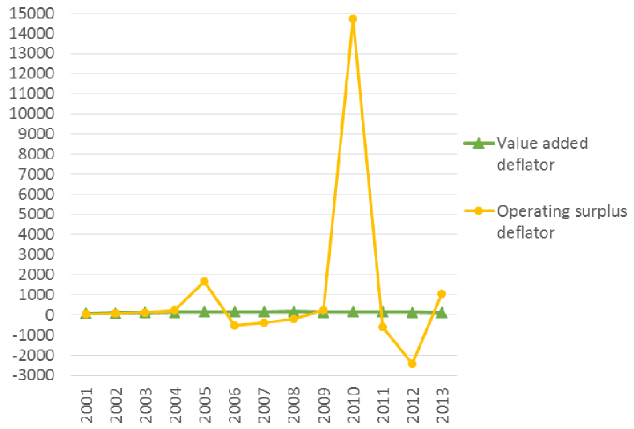

Figure 3-8: Quarrying and pottery

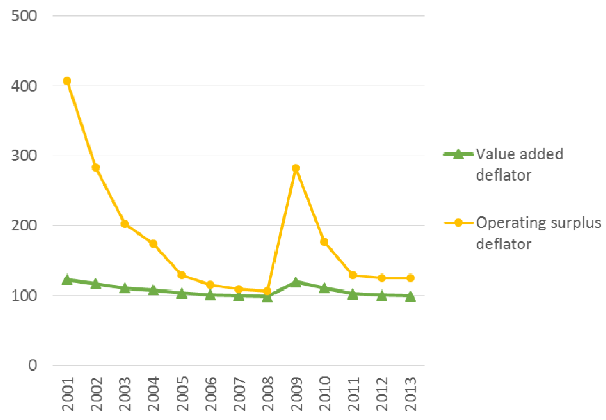

Figure 3-9: Primary metals

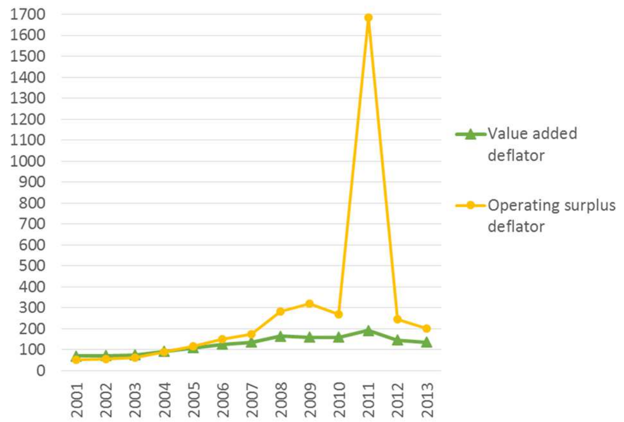

Figure 3-10: Fabricated metal products

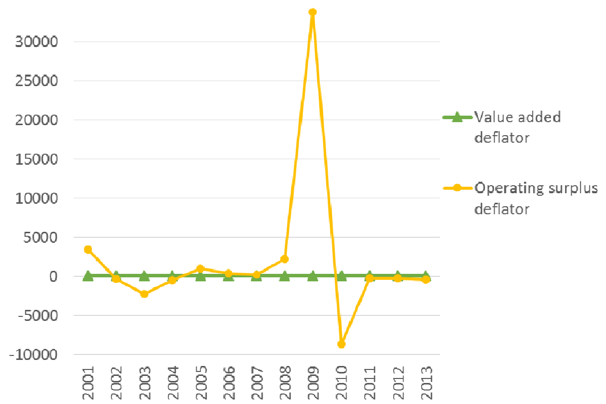

Figure 3-11: General machinery

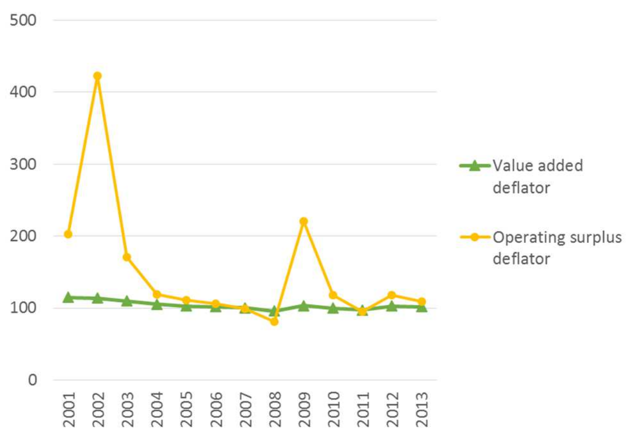

Figure 3-12: Electric machinery and equipment

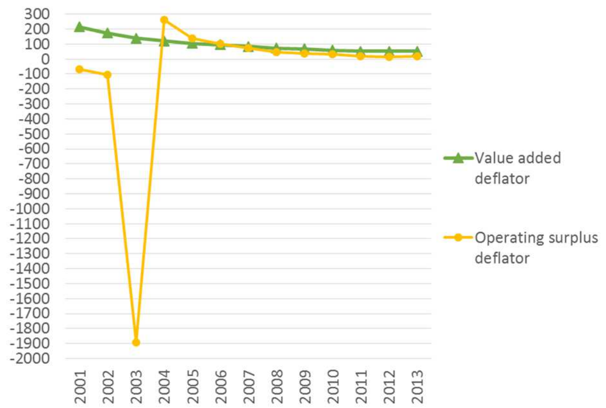

Figure 3-13: Transportation equipment

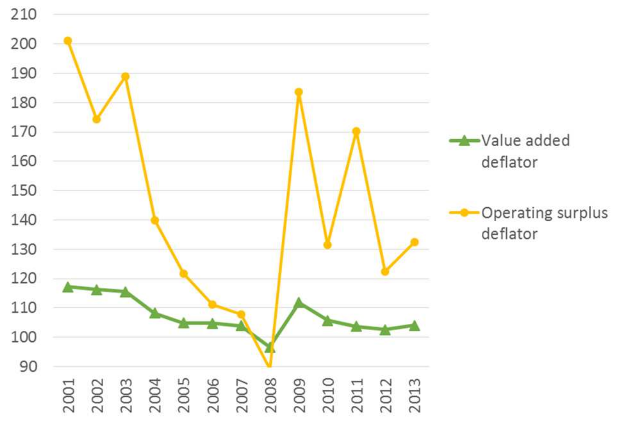

Figure 3-14: Precision equipment

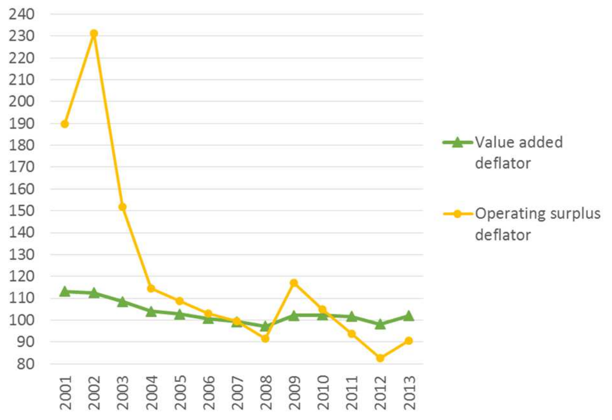

Figure 3-15: Miscellaneous manufacturing

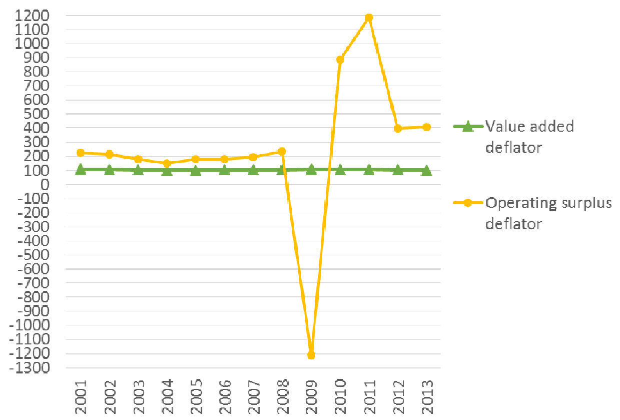

Figure 3-16: Construction

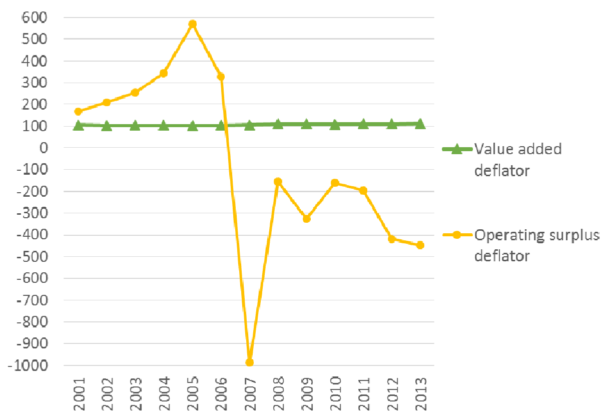

Figure 3-17: Electricity, gas and water supply

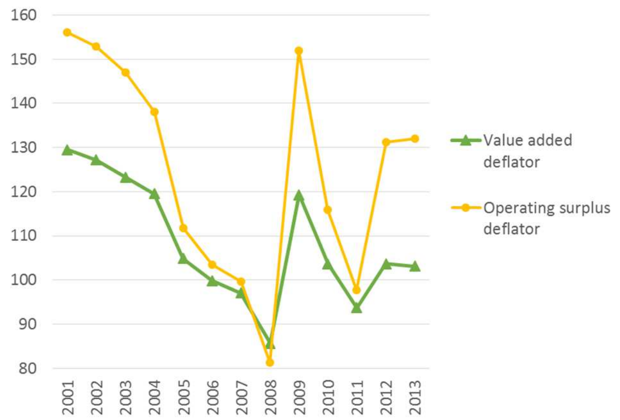

Figure 3-18: Wholesale and retail trade

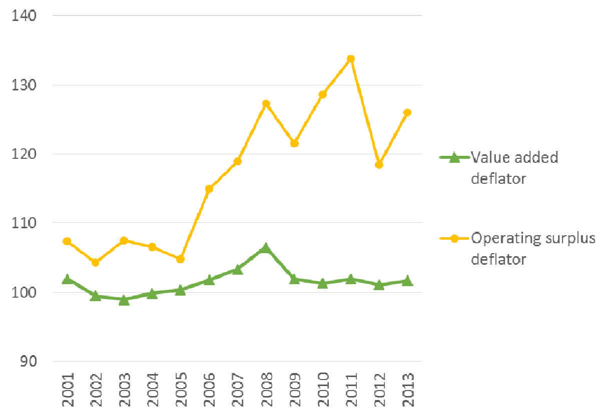

Figure 3-19: Finance and insurance

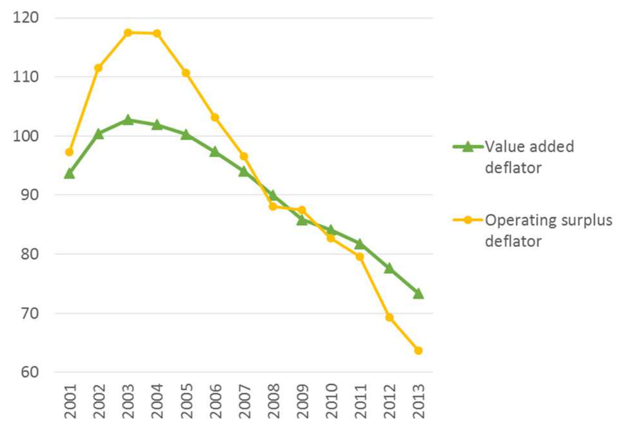

Figure 3-20: Real estate

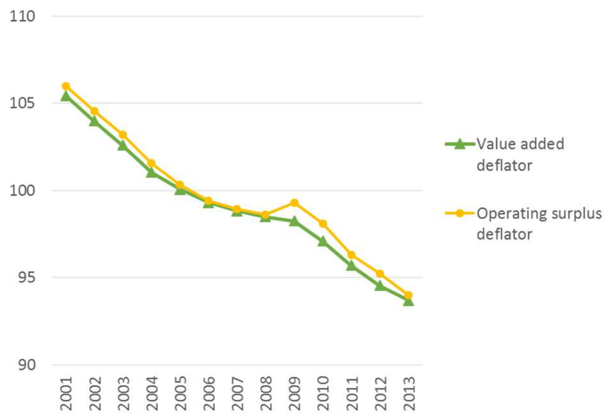

Figure 3-21: Transportation and communication

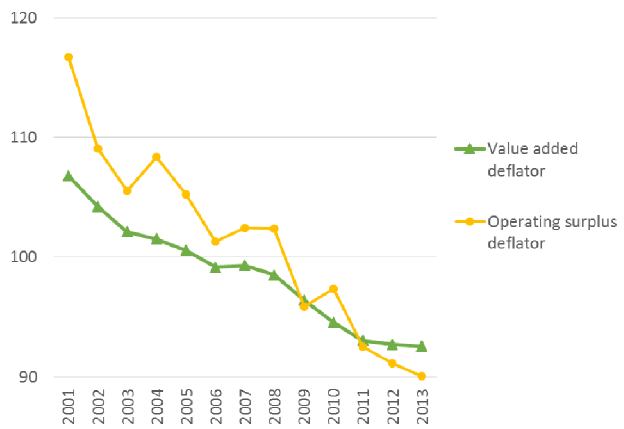

Figure 3-22: Services

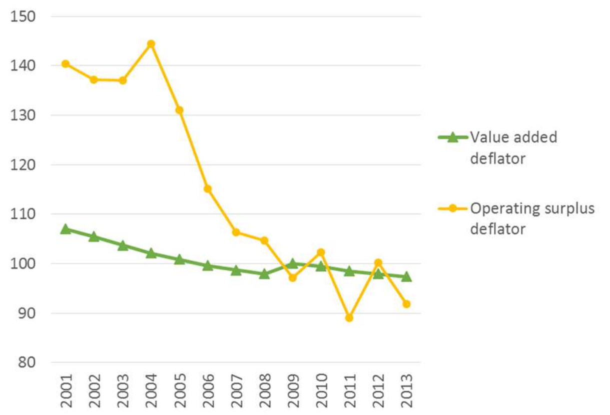

Figure 3-23: Services provided by Government

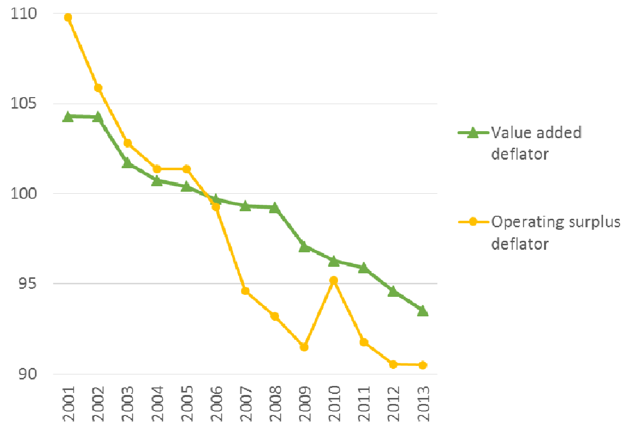

Figure 3-24: Services provided by NPISH

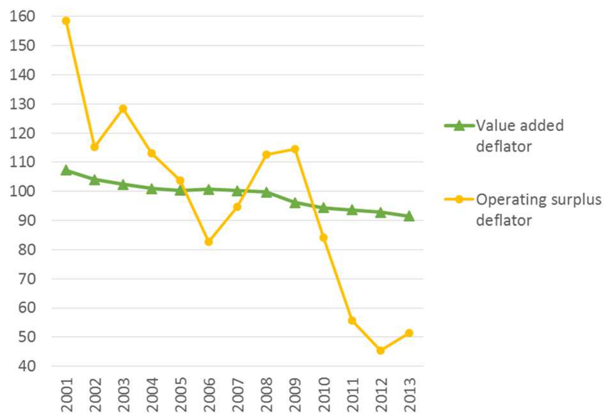

Figure 4: The fluctuations in the wage rate and the tax deflators

Figure 4-1: Agriculture, forestry and fishing

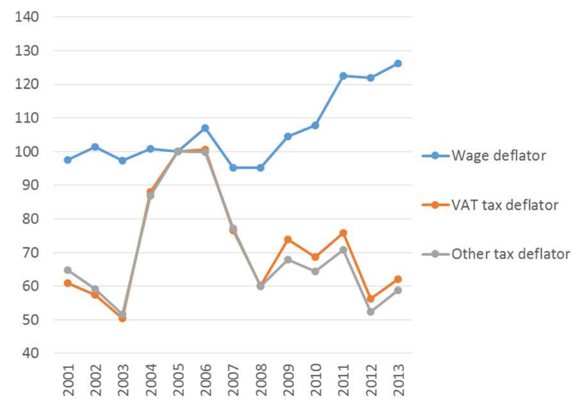

Figure 4-2: Mining

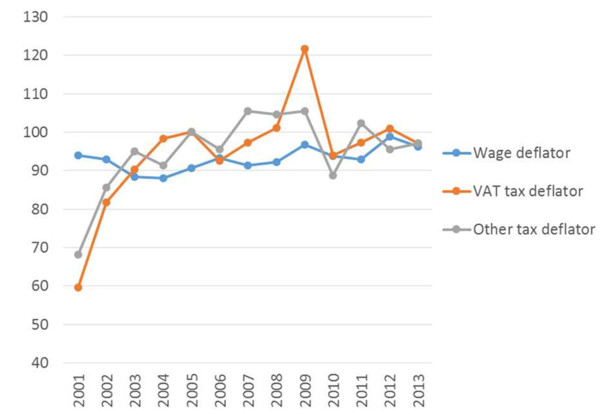

Figure 4-3: Foods and beverages

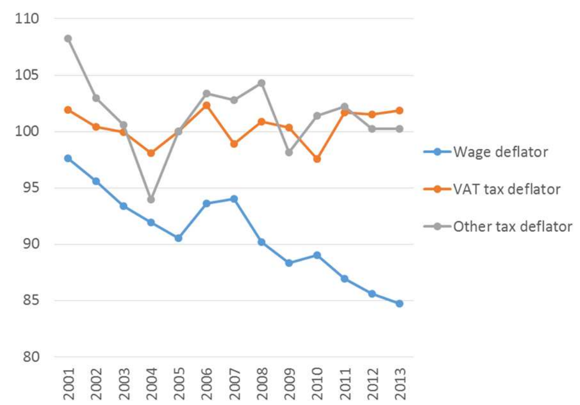

Figure 4-4: Textiles

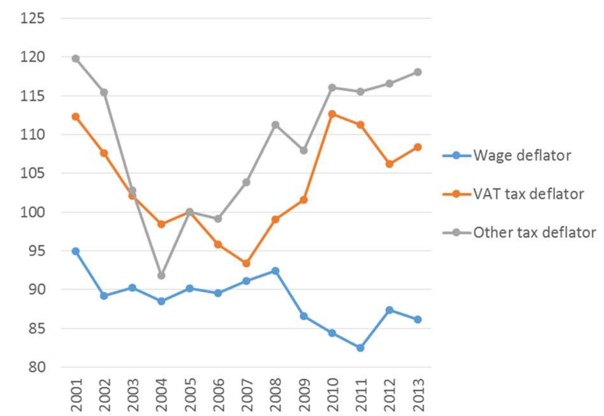

Figure 4-5: Pulp and paper products

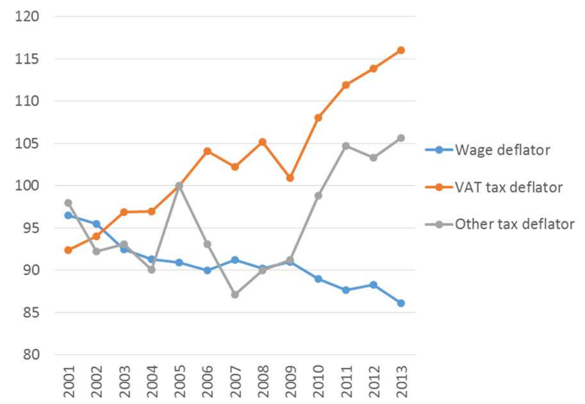

Figure 4-6: Chemical products

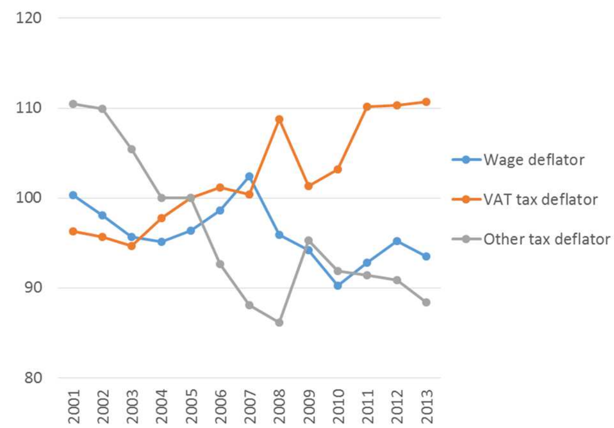

Figure 4-7: Petroleum and coal products

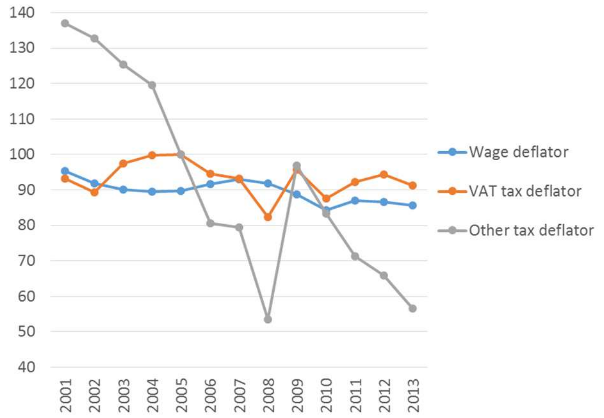

Figure 4-8: Quarrying and pottery

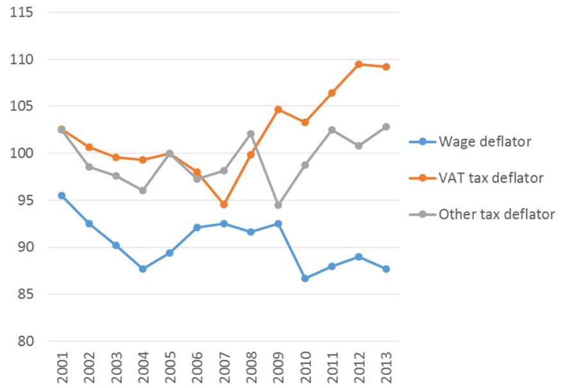

Figure 4-9: Primary metals

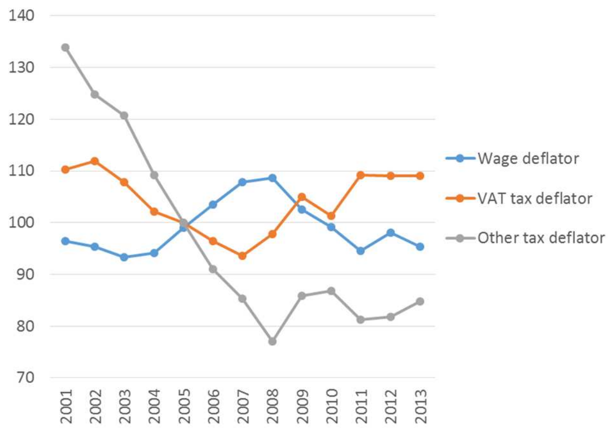

Figure 4-10: Fabricated metal products

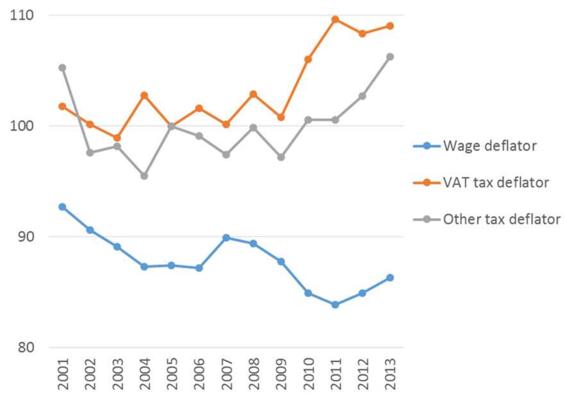

Figure 4-11: General machinery

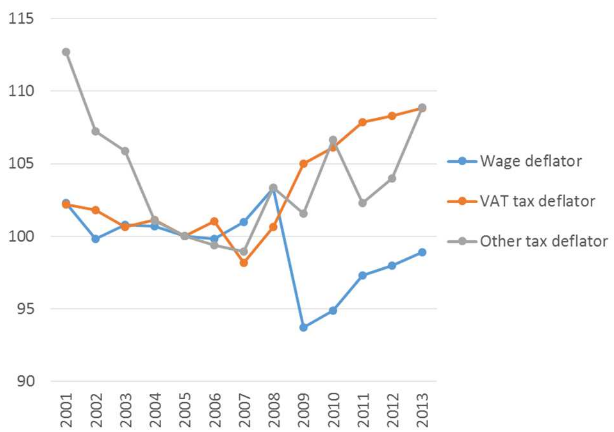

Figure 4-12: Electric machinery and equipment

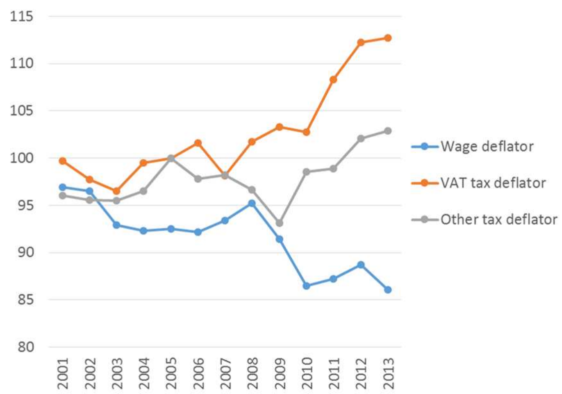

Figure 4-13: Transportation equipment

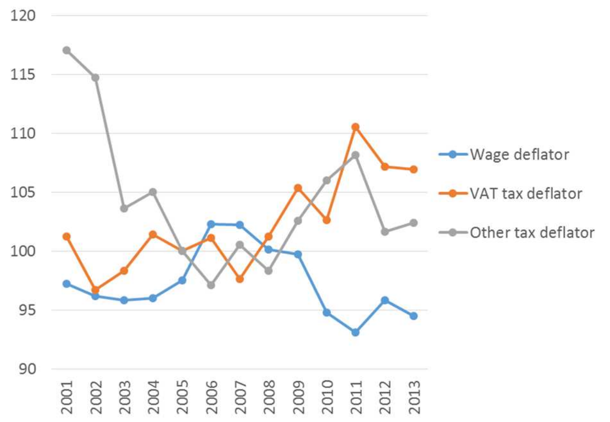

Figure 4-14: Precision equipment

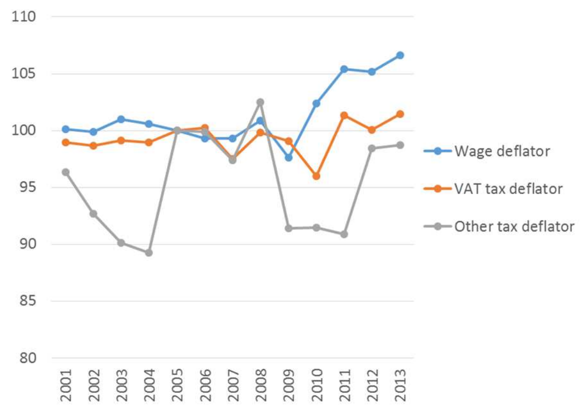

Figure 4-15: Miscellaneous manufacturing

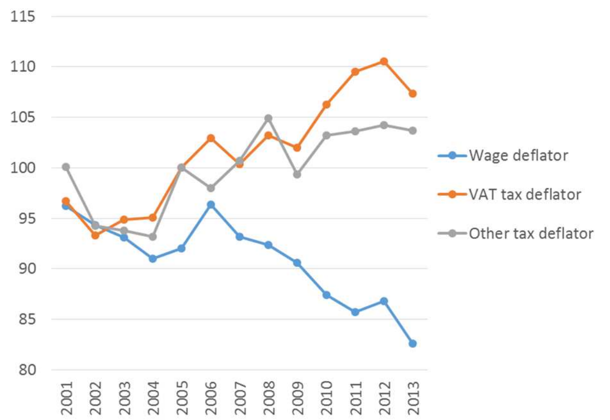

Figure 4-16: Construction

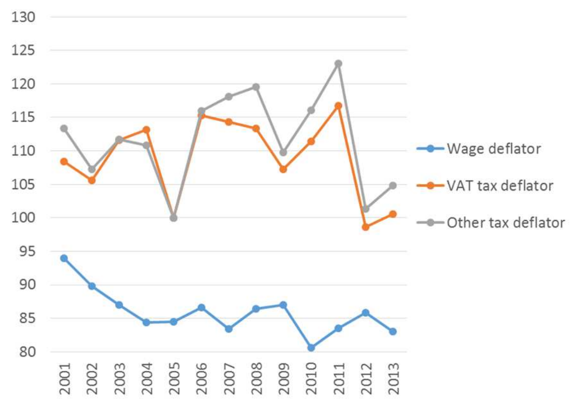

Figure 4-17: Electricity, gas and water supply

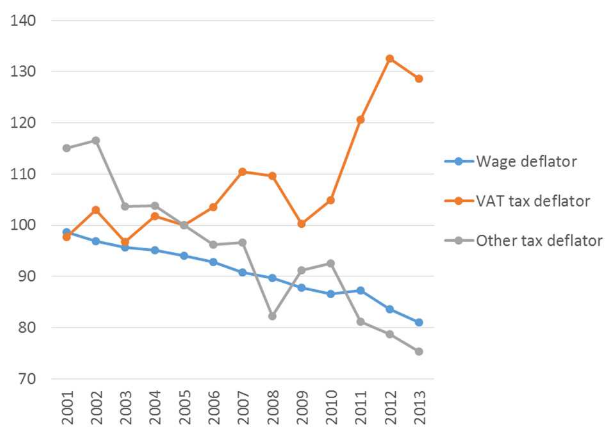

Figure 4-18: Wholesale and retail trade

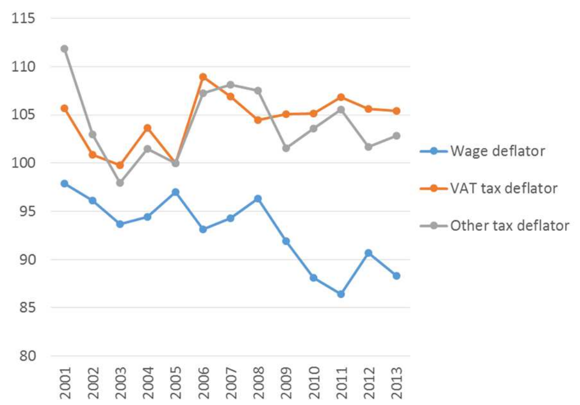

Figure 4-19: Finance and insurance

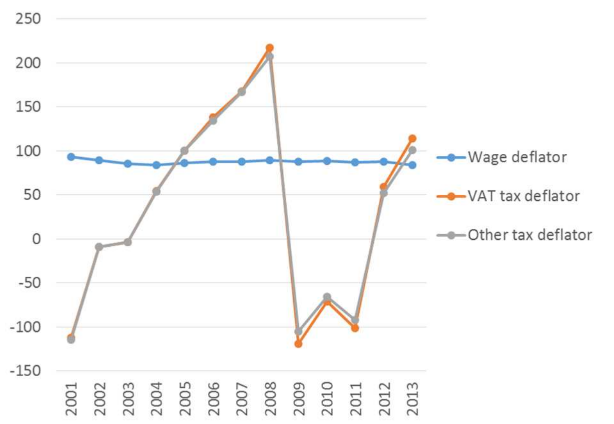

Figure 4-20: Real estate

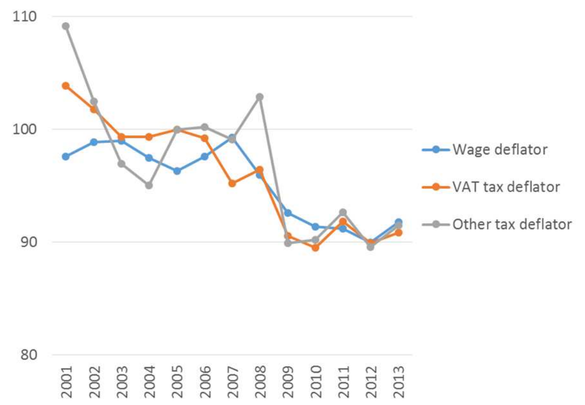

Figure 4-21: Transportation and communication

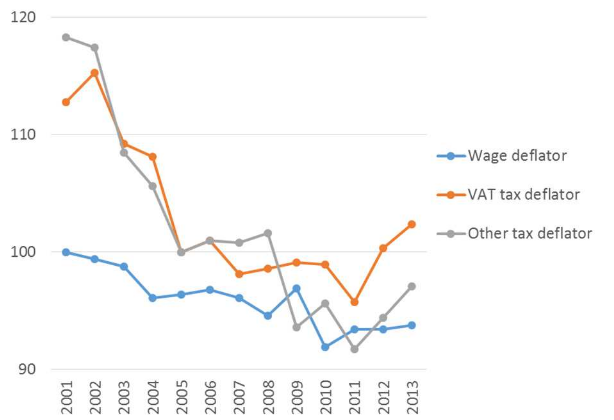

Figure 4-22: Services

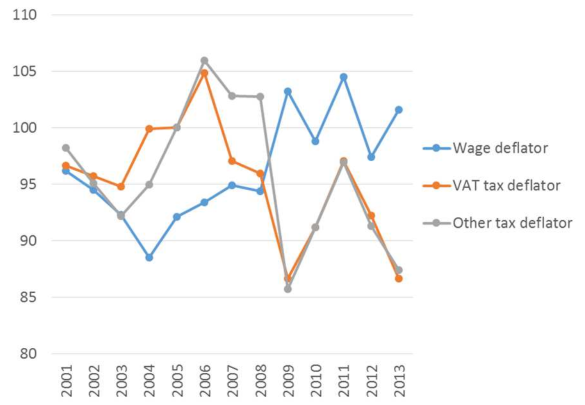

Figure 4-23: Services provided by Government

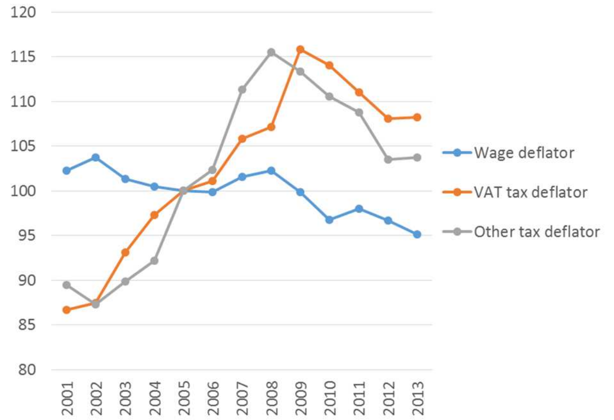

Figure 4-24: Services provided by NPISH

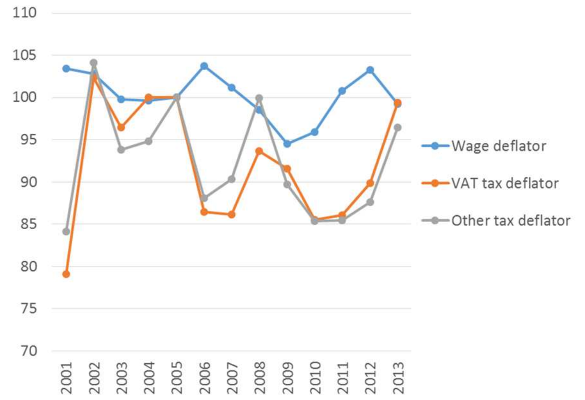

Figure 5: The fluctuations in the deflators for operating surplus, wage rate and the tax deflators across all the sectors

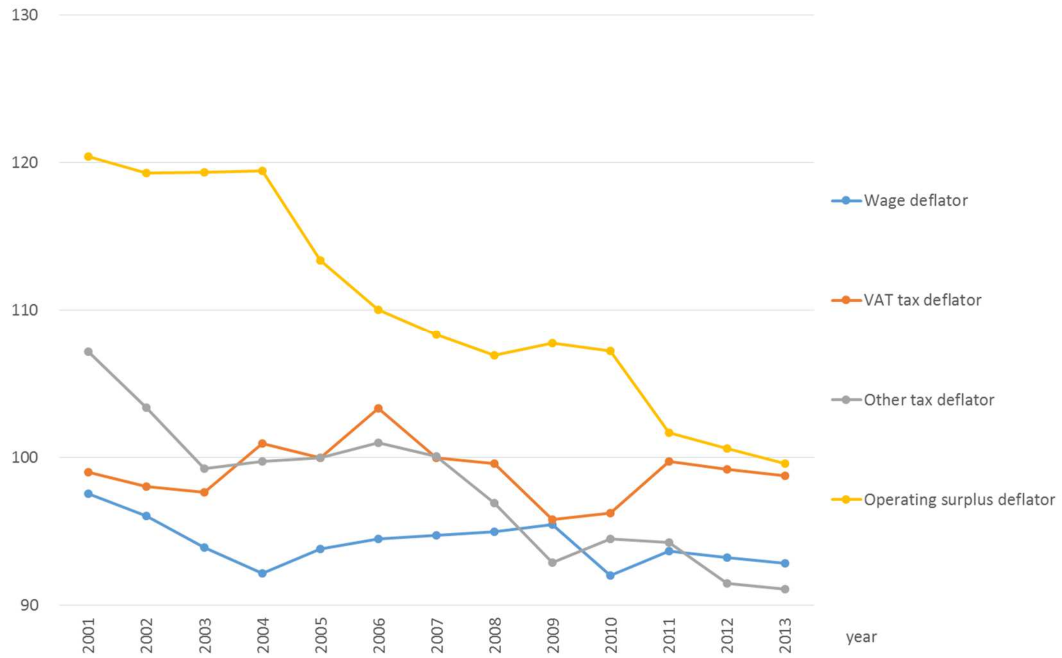

Figure 6: Decomposition of the value added deflator for each sector (2013)

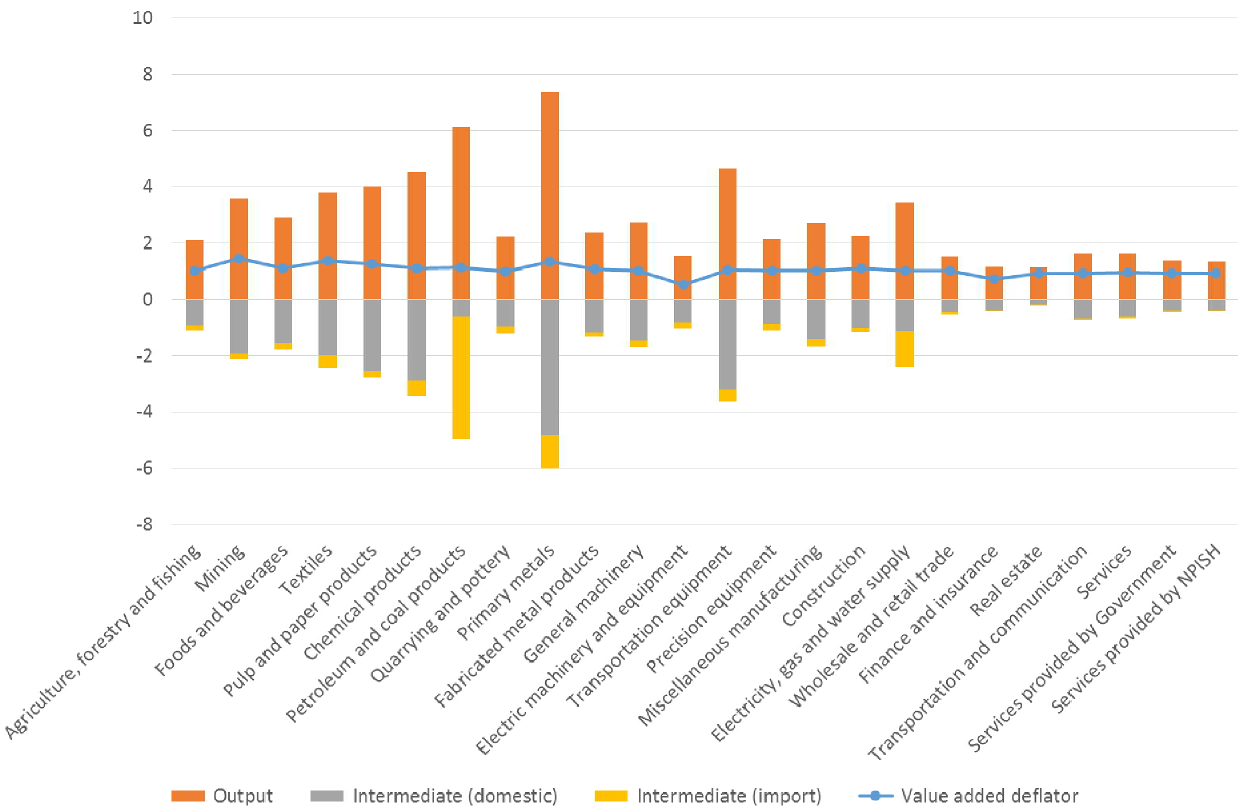

Figure 7: Decomposition of the GDP deflator

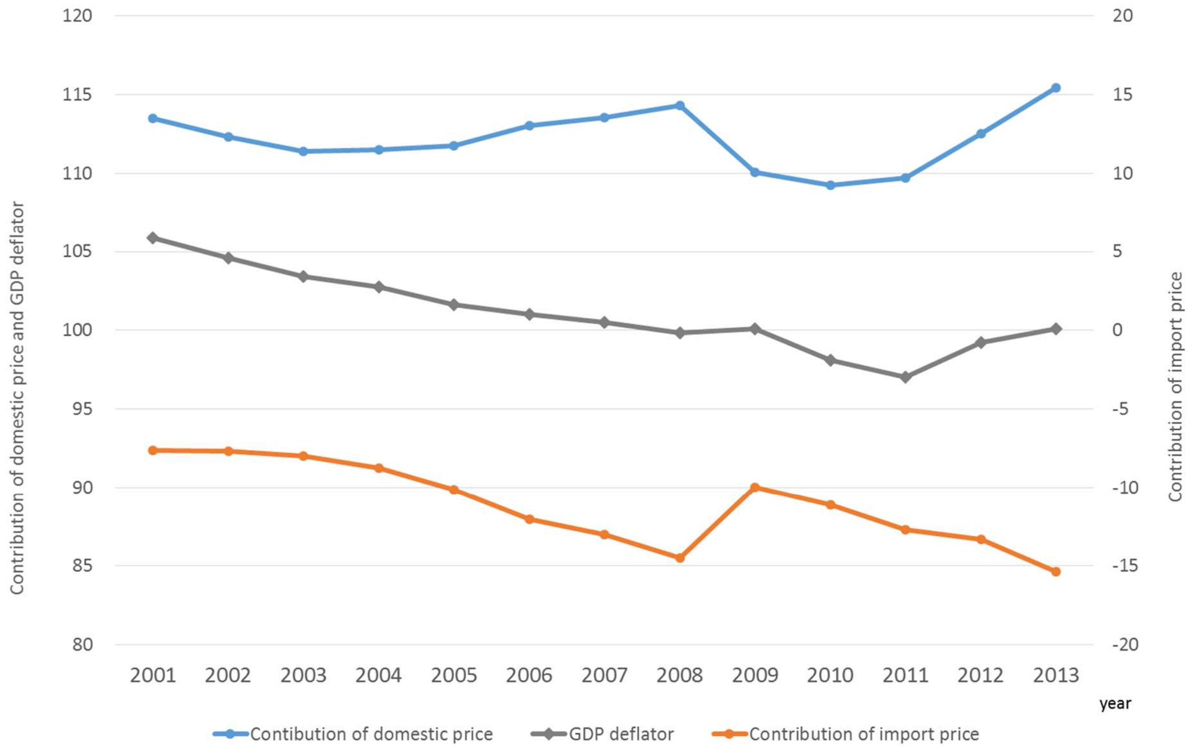

Figure 8: Decomposition of the changes in the GDP deflator (2001-2013)

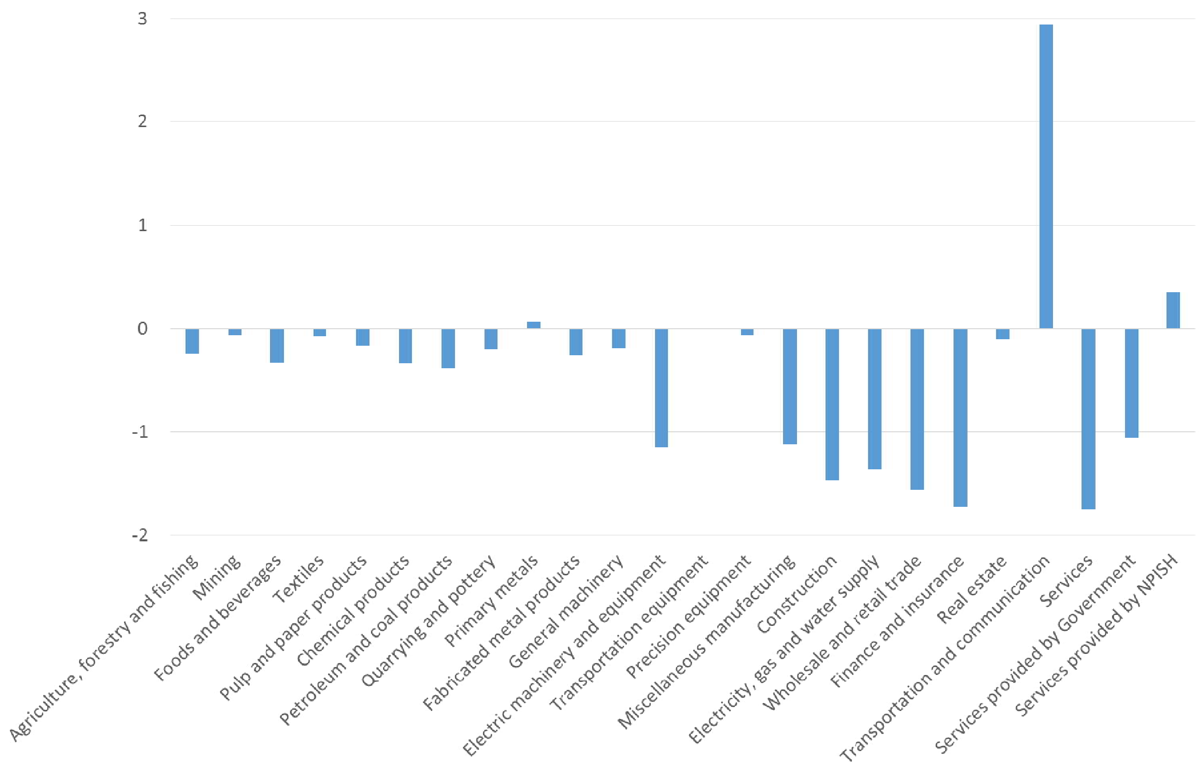

Figure 9: Breakdown of the import input prices