Consumption Growth Accounting

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Abstract

This paper proposes an adapted type of structural decomposition analysis. Its main novelty is its relatively strong supply-side perspective, which renders it more reconcilable with "growth accounting" studies (a popular tool in mainstream economics). Three kinds of effects are assumed to affect intertemporal changes in consumption per worker. The first type relates consumption growth to technological change. More detailed effects that can be discerned are due to changing intermediate input requirements, changing demand for investment purposes and changing labor productivity at the industry level. Sources of such industry-level labor productivity growth could be analyzed further by means of industry-level growth accounting analysis. The second kind of effects are due to changes in international trade. Increased imports free up scarce labor resources, but increased exports require more labor that could have been used to produce consumption goods otherwise. Finally, shifts in the compositions of export and consumption demand can lead to structural shifts towards labor-intensive or labor-extensive industries. The methodology allows for quantification of the relative contributions of these factors. The method is illustrated by a study into the British experience, 1979-1990.

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1. Introduction

Recently, Eric Davidson published a book titled "You Can't Eat GNP" (Davidson, 2000), in which he argued that economists should not focus solely on output or productivity indicators to assess the performance of an economy. In the book, he argued that ecological issues should also be taken into account. In this paper, we propose a methodology based on input-output economics that also starts from the perspective that GNP or GDP per capita do not indicate welfare. The production of huge amounts of capital goods, or an upsurge in the output of exported products do not necessarily lead to more welfare. Disregarding the sustainability issues emphasized by Davidson, it is consumption growth that offers a better indicator of welfare growth. The methodolgy to be developed in this paper aims at giving quantifications for the contributions of technological progress, changes in tastes and changing trade patterns to consumption growth.

The title of the paper suggests a link between well-known growth accounting and our methodology. The rest of this introduction aims at explaining this link as well as its relation to earlier accounting studies in input-output economics. In traditional neoclassical economics, exogenous levels of capital and labor inputs (together with exogenous total factor productivity levels) are seen as the determinants of endogenous output levels. In other words, output is seen as being supply-driven. Consequently, neoclassical "growth accounting" studies attribute endogenous GDP per worker growth to two effects: exogenously increased capital intensity levels and exogenous technological progress. Pioneering studies were Abramovitz (1956), Solow (1957) and Denison (1967), among others. Nowadays, growth accounting methodologies have become an important tools in wide-ranging academic activities, such as predicting the future economic performance of quickly catching-up East-Asian countries (e.g. Young, 1995) and assessing the impacts of information technology on productivity growth (e.g. Jorgenson, 2001, and Timmer *et al.*, 2003).[1] Growth accounting methods can also be applied at the level of industries. If industry-level results are available for a substantial part of the economy, the aggregate productivity effects of intertemporal shifts of labor and/or capital from one industry to another can also be quantified (see Paci and Pigliaru, 1997, and Timmer and Szirmai, 2000). Generally, such studies do not address the question of what factors drive structural change, since the input levels are considered as exogenous variables.

Another field within economics, input-output economics, focuses on this specific issue of changes in the interindustry structure. Most often, the point of departure is the static open input-output model, which views the exogenous levels of consumption demand, investment demand and export demand for each of the specified products (together with the exogenous input requirements)[2] as the main determinants of endogenous output and employment levels. Output is thus a demand-driven variable. One of the empiricals tool developed in this field is "structural decomposition analysis". In it's most basic form, it attributes intertemporal changes in output levels to contributions of changes in the demand levels for each of the sectors and to changes in

[1] Since long, more specific inputs than raw labor and capital have been included in growth accounting exercises. Examples are labor of different skills and several classes of capital goods, such as information technology capital.

[2] These input coefficients can be seen as input productivity parameters.

the input coefficients. The required data are contained in input-output tables. Probably, the most well-known contribution to this literature is Carter (1970), which was basically replicated in a more recent study by Feldman *et al*. (1985). Wolff (1985) showed that structural decomposition analyses can also be used to study changes in national total factor productivity levels. Dietzenbacher *et al*. (2000) extended parts of his approach to decompose labor productivity growth rates in the European Union.

The above description indicates that "growth accounting" studies and "structural decomposition analyses" attempt at gaining insights into similar phenomena. In theory, they should be complementary, in the sense that they focus on different aspects of the growth process that do not necessarily conflict. In practice, however, growth accounting and structural decomposition analysis did not benefit much from each other. In our view, this is mainly due to conflicting viewpoints with regard to the nature of mechanisms that drive output. Authors in the growth accounting tradition take a supply-side perspective. Basically, available resources and their productivity levels are assumed to determine how much is produced, irrespective of the demand conditions. Scholars doing structural decomposition analyses generally take the opposite perspective. Demand determines what is produced, and supply of resources will adapt to these production levels. As a consequence, the typical results of growth accounting studies and structural decomposition analyses are hard to reconcile. Especially for developed countries in which investment rates are relatively stable, technological change is often found to be an important driver of value added change in growth accounts, whereas the same phenomenon is often ascribed to growth in consumption and investment demand in structural decomposition analysis studies.

The aim of the methodology outlined in this paper is to reconcile both approaches. To this end, a new structural decomposition analysis tool is proposed, which largely takes a supply-side perspective. Labor supply is given. The input-output approach to structural change, however, is preserved. Another novel aspect is that the use of detailed input-output tables offers opportunities for an analysis of consumption growth instead of GDP growth, which we view as an advantage in view of the above-mentioned arguments. Further, we show that our approach can also take the effects of changing trade patterns into account, data availability permitting.

The rest of the paper is organized as follows. In Section 2, we will describe the methodology in formal terms, deriving the equations that give the contributions of the specified determinants to total consumption per person engaged growth from a supply-driven input-output model. Section 3 is devoted to an empirical illlustration. We apply our consumption growth accounting framework to input-output tables and employment data for the United Kingdom in the period 1979-1990. Section 4 concludes.

2. Methodology

In static open demand-driven input-output models (the most common type of input-output models), the level of labor demand is given by $L^{dem} = \mathbf{l}'\mathbf{x}$ (**l**: labor requirements per unit of gross output, **x**: gross output levels).[3] Output levels are partly endogenous and partly exogenous. The levels of consumption demand, investment demand and export demand (together called "final demand") are exogenous. Because their production requires materials ("intermediate inputs") that have to be produced themselves, gross output levels are generally higher than final demand levels. The differences between these levels are endogenous and depend on the production structure as represented by the input coefficients contained in the matrix **A**. Each column of A corresponds to an industry. The elements of such a column indicate the requirements of each of the intermediate inputs per unit of gross output in the industry considered. As is well known from input-output textbooks (such as Miller and Blair, 1985), successive rounds of production of intermediate inputs required for intermediate inputs required for the production of final demand commodities leads to $\mathbf{x} = \mathbf{Lf}$, with **f** representing final demand and **L** indicating the Leontief inverse ($\mathbf{L} = \mathbf{I} + \mathbf{A} + \mathbf{A}^2 + ... = (\mathbf{I} - \mathbf{A})^{-1}$). Thus, according to the static open demand-driven input-output model, labor demand can be expressed as $L^{dem} = \mathbf{l}'\mathbf{Lf}$. Given the input coefficients and the labor coefficients, the exogenous level of final demand fixes endogenous labor demand.

To share the property of supply-side determination of output levels with the growth accounting framework, we will first formulate a supply-driven input-output model. It is a simplified version of the short-run part of the dynamic model introduced by Los (2001). The output levels are assumed to be exactly as high as required to meet labor supply:

$$\mathbf{l}'\mathbf{x} = L^{sup} . \tag{1}$$

Assuming that each unit of output can be used domestically either as an intermediate input, as a consumption good or as a capital good, or can be exported, the output vector can be written as

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}(\mathbf{c} + \mathbf{in} + \mathbf{e}) \tag{2}$$

Further the consumption vector **c** can be written as the product of the vector with commodity shares in total consumption $\mathbf{b^C}$ and the total consumption level *C*. Substituting this product into (2) and subsequently substituting the result into (1) and solving for *C* yields:

$$C = \frac{L^{sup}}{\mathbf{l}'(\mathbf{I} - \mathbf{A})^{-1}\mathbf{b}^{\mathrm{C}}} - \frac{\mathbf{l}'(\mathbf{I} - \mathbf{A})^{-1}(\mathbf{in} + \mathbf{e})}{\mathbf{l}'(\mathbf{I} - \mathbf{A})^{-1}\mathbf{b}^{\mathrm{C}}} \tag{3}$$

Equation (3) gives the maximum consumption level which can be attained given labor supply (L^{sup}), the industry-specific technologies (represented by **l** and **A**) and the consumption shares ($\mathbf{b^C}$), assuming that production for investment and foreign purposes are fixed. Indirectly, production for the latter purposes reduces labor demands per unit of output. If no capital goods were produced, all output would have had to be produced by labor alone, while exports enable a country to buy commodities from abroad instead of producing them itself using its scarce labor.

[3] Throughout the paper, we will use italic symbols to denote scalars. Capital italics refer to values for the economy considered as a whole, lowercase italics indicate values expressed in per capita terms. Bold lowercase symbols will be used to indicate vectors, and bold capitals to represent matrices. Primes indicate transposed vectors or matrices. Hats are used to denote diagonalized vectors. Unless mentioned otherwise, dimensions of (column) vectors and matrices are (*n*x1) and (*n*x*n*), respectively, with *n* representing the number of industries.

From a static viewpoint, however, the input of labor to produce investment goods and export goods reduces the labor resources available for the production of consumption goods. An extended version of (3) would read:

$$C = \frac{L^{sup}}{\mathbf{l}'(\mathbf{I}-\mathbf{D}^{\mathbf{A}} \circ \mathbf{A})^{-1}(\mathbf{d}^{\mathbf{C}} \circ \mathbf{b}^{\mathbf{C}})} - \frac{\mathbf{l}'(\mathbf{I}-\mathbf{D}^{\mathbf{A}} \circ \mathbf{A})^{-1}(\mathbf{d}^{\mathbf{IN}} \circ \{\mathbf{b}^{\mathbf{IN}} \cdot IN\} + \mathbf{d}^{\mathbf{E}} \circ \{\mathbf{b}^{\mathbf{E}} \cdot E\})}{\mathbf{l}'(\mathbf{I}-\mathbf{D}^{\mathbf{A}} \circ \mathbf{A})^{-1}(\mathbf{d}^{\mathbf{C}} \circ \mathbf{b}^{\mathbf{C}})} \quad , \qquad (4)$$

with the matrix **D** and vectors **d** representing the proportions of demand which are produced domestically and the ‘bridge’ vectors **b** indicating the commodity shares in total consumption, investment and exports. Given this expression, changes in the total consumption level can be attributed to changes in the values of the variables represented by the symbols in the right hand side of equation (4). To get insights into determinants of welfare changes, it is useful to consider changes in consumption per worker, for which an expression can be found by simply dividing both sides of equation (4) by L^{sup}:

$$\frac{C}{L^{sup}} = \frac{1}{\mathbf{l}'(\mathbf{I}-\mathbf{D}^{\mathbf{A}} \circ \mathbf{A})^{-1}(\mathbf{d}^{\mathbf{C}} \circ \mathbf{b}^{\mathbf{C}})} - \frac{\mathbf{l}'(\mathbf{I}-\mathbf{D}^{\mathbf{A}} \circ \mathbf{A})^{-1}(\mathbf{d}^{\mathbf{IN}} \circ \{\mathbf{b}^{\mathbf{IN}} \cdot [IN/L^{sup}]\} + \mathbf{d}^{\mathbf{E}} \circ \{\mathbf{b}^{\mathbf{E}} \cdot [E/L^{sup}]\})}{\mathbf{l}'(\mathbf{I}-\mathbf{D}^{\mathbf{A}} \circ \mathbf{A})^{-1}(\mathbf{d}^{\mathbf{C}} \circ \mathbf{b}^{\mathbf{C}})} \qquad (5)$$

From now on, the equations will be expressed in $c \equiv \frac{C}{L^{\text{sup}}}$, $in \equiv \frac{IN}{L^{\text{sup}}}$, $e \equiv \frac{E}{L^{\text{sup}}}$. The ratio of consumption per unit of labor in two periods (indicated by indices 0 and 1) can be written as:[4]

$$\frac{c_1}{c_0} = \frac{1-\mathbf{l}_1'(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}} \circ \mathbf{A}_1)^{-1}(\mathbf{d}_1^{\mathbf{IN}} \circ \{\mathbf{b}_1^{\mathbf{IN}} in_1\} + \mathbf{d}_1^{\mathbf{E}} \circ \{\mathbf{b}_1^{\mathbf{E}} e_1\})}{1-\mathbf{l}_0'(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}} \circ \mathbf{A}_0)^{-1}(\mathbf{d}_0^{\mathbf{IN}} \circ \{\mathbf{b}_0^{\mathbf{IN}} in_0\} + \mathbf{d}_0^{\mathbf{E}} \circ \{\mathbf{b}_0^{\mathbf{E}} e_0\})} \cdot \frac{\mathbf{l}_0'(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}} \circ \mathbf{A}_0)^{-1}(\mathbf{d}_0^{\mathbf{C}} \circ \mathbf{b}_0^{\mathbf{C}})}{\mathbf{l}_1'(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}} \circ \mathbf{A}_1)^{-1}(\mathbf{d}_1^{\mathbf{C}} \circ \mathbf{b}_1^{\mathbf{C}})} \qquad (6)$$

Now, the methodology proposed by Dietzenbacher *et al*. (2000) can be used to express the right hand side of equation (6) as the product of consumption per unit of labor changes which would have been observed if only a single variable would have changed between period 0 and period 1:

$$\frac{c_1}{c_0} = (7.1)\cdot(7.2)\cdot(7.3)\cdot(7.4)\cdot(7.5)\cdot(7.6)\cdot(7.7)\cdot(7.8)\cdot(7.9)\cdot(7.10)\cdot(7.11) \qquad (7)$$

with

[4] It should be mentioned that equation (6) only holds exactly if the investment vector does not contain negative entries.

$$(7.1) = \frac{1-\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_1^{\mathbf{IN}}\circ\left\{\mathbf{b}_1^{\mathbf{IN}}in_1\right\}+\mathbf{d}_1^{\mathbf{E}}\circ\left\{\mathbf{b}_1^{\mathbf{E}}e_1\right\}\right)}{1-\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_1^{\mathbf{IN}}\circ\left\{\mathbf{b}_1^{\mathbf{IN}}in_1\right\}+\mathbf{d}_1^{\mathbf{E}}\circ\left\{\mathbf{b}_1^{\mathbf{E}}e_1\right\}\right)}\cdot\frac{\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_1^{\mathbf{C}}\circ\mathbf{b}_1^{\mathbf{C}}\right)}{\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_1^{\mathbf{C}}\circ\mathbf{b}_1^{\mathbf{C}}\right)}$$

$$(7.2) = \frac{1-\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_1^{\mathbf{IN}}\circ\left\{\mathbf{b}_1^{\mathbf{IN}}in_1\right\}+\mathbf{d}_1^{\mathbf{E}}\circ\left\{\mathbf{b}_1^{\mathbf{E}}e_1\right\}\right)}{1-\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_1^{\mathbf{IN}}\circ\left\{\mathbf{b}_1^{\mathbf{IN}}in_1\right\}+\mathbf{d}_1^{\mathbf{E}}\circ\left\{\mathbf{b}_1^{\mathbf{E}}e_1\right\}\right)}\cdot\frac{\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_1^{\mathbf{C}}\circ\mathbf{b}_1^{\mathbf{C}}\right)}{\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_1^{\mathbf{C}}\circ\mathbf{b}_1^{\mathbf{C}}\right)}$$

$$(7.3) = \frac{1-\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_1^{\mathbf{IN}}\circ\left\{\mathbf{b}_1^{\mathbf{IN}}in_1\right\}+\mathbf{d}_1^{\mathbf{E}}\circ\left\{\mathbf{b}_1^{\mathbf{E}}e_1\right\}\right)}{1-\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_1^{\mathbf{IN}}\circ\left\{\mathbf{b}_0^{\mathbf{IN}}in_1\right\}+\mathbf{d}_1^{\mathbf{E}}\circ\left\{\mathbf{b}_1^{\mathbf{E}}e_1\right\}\right)}$$

$$(7.4) = \frac{1-\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_1^{\mathbf{IN}}\circ\left\{\mathbf{b}_0^{\mathbf{IN}}in_1\right\}+\mathbf{d}_1^{\mathbf{E}}\circ\left\{\mathbf{b}_1^{\mathbf{E}}e_1\right\}\right)}{1-\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_1^{\mathbf{IN}}\circ\left\{\mathbf{b}_0^{\mathbf{IN}}in_1\right\}+\mathbf{d}_1^{\mathbf{E}}\circ\left\{\mathbf{b}_0^{\mathbf{E}}e_1\right\}\right)}$$

$$(7.5) = \frac{1-\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_1^{\mathbf{IN}}\circ\left\{\mathbf{b}_0^{\mathbf{IN}}in_1\right\}+\mathbf{d}_1^{\mathbf{E}}\circ\left\{\mathbf{b}_0^{\mathbf{E}}e_1\right\}\right)}{1-\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_1^{\mathbf{IN}}\circ\left\{\mathbf{b}_0^{\mathbf{IN}}in_1\right\}+\mathbf{d}_1^{\mathbf{E}}\circ\left\{\mathbf{b}_0^{\mathbf{E}}e_1\right\}\right)}\cdot\frac{\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_1^{\mathbf{C}}\circ\mathbf{b}_0^{\mathbf{C}}\right)}{\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_1^{\mathbf{C}}\circ\mathbf{b}_1^{\mathbf{C}}\right)}$$

$$(7.6) = \frac{1-\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_1^{\mathbf{IN}}\circ\left\{\mathbf{b}_0^{\mathbf{IN}}in_1\right\}+\mathbf{d}_1^{\mathbf{E}}\circ\left\{\mathbf{b}_0^{\mathbf{E}}e_1\right\}\right)}{1-\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_1^{\mathbf{IN}}\circ\left\{\mathbf{b}_0^{\mathbf{IN}}in_1\right\}+\mathbf{d}_1^{\mathbf{E}}\circ\left\{\mathbf{b}_0^{\mathbf{E}}e_1\right\}\right)}\cdot\frac{\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_1^{\mathbf{C}}\circ\mathbf{b}_0^{\mathbf{C}}\right)}{\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_1^{\mathbf{C}}\circ\mathbf{b}_0^{\mathbf{C}}\right)}$$

$$(7.7) = \frac{1-\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_1^{\mathbf{IN}}\circ\left\{\mathbf{b}_0^{\mathbf{IN}}in_1\right\}+\mathbf{d}_1^{\mathbf{E}}\circ\left\{\mathbf{b}_0^{\mathbf{E}}e_1\right\}\right)}{1-\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_0^{\mathbf{IN}}\circ\left\{\mathbf{b}_0^{\mathbf{IN}}in_1\right\}+\mathbf{d}_1^{\mathbf{E}}\circ\left\{\mathbf{b}_0^{\mathbf{E}}e_1\right\}\right)}$$

$$(7.8) = \frac{1-\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_0^{\mathbf{IN}}\circ\left\{\mathbf{b}_0^{\mathbf{IN}}in_1\right\}+\mathbf{d}_1^{\mathbf{E}}\circ\left\{\mathbf{b}_0^{\mathbf{E}}e_1\right\}\right)}{1-\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_0^{\mathbf{IN}}\circ\left\{\mathbf{b}_0^{\mathbf{IN}}in_1\right\}+\mathbf{d}_0^{\mathbf{E}}\circ\left\{\mathbf{b}_0^{\mathbf{E}}e_1\right\}\right)}$$

$$(7.9) = \frac{1-\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_0^{\mathbf{IN}}\circ\left\{\mathbf{b}_0^{\mathbf{IN}}in_1\right\}+\mathbf{d}_0^{\mathbf{E}}\circ\left\{\mathbf{b}_0^{\mathbf{E}}e_1\right\}\right)}{1-\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_0^{\mathbf{IN}}\circ\left\{\mathbf{b}_0^{\mathbf{IN}}in_1\right\}+\mathbf{d}_0^{\mathbf{E}}\circ\left\{\mathbf{b}_0^{\mathbf{E}}e_1\right\}\right)}\cdot\frac{\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_0^{\mathbf{C}}\circ\mathbf{b}_0^{\mathbf{C}}\right)}{\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_1^{\mathbf{C}}\circ\mathbf{b}_0^{\mathbf{C}}\right)}$$

$$(7.10) = \frac{1-\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_0^{\mathbf{IN}}\circ\left\{\mathbf{b}_0^{\mathbf{IN}}in_1\right\}+\mathbf{d}_0^{\mathbf{E}}\circ\left\{\mathbf{b}_0^{\mathbf{E}}e_1\right\}\right)}{1-\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_0^{\mathbf{IN}}\circ\left\{\mathbf{b}_0^{\mathbf{IN}}in_0\right\}+\mathbf{d}_0^{\mathbf{E}}\circ\left\{\mathbf{b}_0^{\mathbf{E}}e_1\right\}\right)}$$

$$(7.11) = \frac{1-\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_0^{\mathbf{IN}}\circ\left\{\mathbf{b}_0^{\mathbf{IN}}in_0\right\}+\mathbf{d}_0^{\mathbf{E}}\circ\left\{\mathbf{b}_0^{\mathbf{E}}e_1\right\}\right)}{1-\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_0^{\mathbf{IN}}\circ\left\{\mathbf{b}_0^{\mathbf{IN}}in_0\right\}+\mathbf{d}_0^{\mathbf{E}}\circ\left\{\mathbf{b}_0^{\mathbf{E}}e_0\right\}\right)}$$

The factors (7.1) and (7.2) indicate how much changes in the production technologies contributed to the aggregate change in consumption per unit of labor. (7.1) gives the hypothetical rate of growth of consumption per worker if only the labor input coefficients per unit of gross output **l** would have changed. In a similar vein, (7.2) gives the change that would have occurred if only the intermediate input coefficients would have changed and everything else would have remained constant.

Factors (7.3)-(7.5) reflect changes in the total consumption per unit of labor attainable due to changes of the commodity shares in investment demand, export demand and consumption demand, respectively. These contributions might be substantial if demand shifted from commodities the production processes of which require relatively small labor inputs and relatively few labor-intensive intermediate inputs, or vice versa.

Factors (7.6)-(7.9) give the effects of changing import patterns. If an economy is able to increase its imports without increasing its exports to the same extent, a larger part of the labor supply can be allocated to produce commodities for consumption purposes. A similar effect could be observed when international specialization leads to increasing imports of labor-intensive commodities and increasing exports of labor-extensive products. It should be noted that factor (7.8) will generally yield a ratio very close to 1.0, because exports are domestically produced by definition, although treatment of transit flows in the construction of input-output tables can lead to other results.

Finally, factors (7.10) and (7.11) indicate how much consumption per unit of labor would have changed if only investment demand per unit of labor and export demand per unit of labor would have changed. The former factor partly reflects technological change, since labor-saving innovations will increase the capital-labor ratio and therefore raise investment demand per worker.

Dietzenbacher and Los (1998) showed that the magnitudes of the contributions of the sources of growth as found in structural decomposition analyses can depend heavily on the specific decomposition equation chosen.[5] One could, for example, also opt for an equation in which all indices 1 in equation (7) are replaced by indices 0, and vice versa. De Haan (2001) coined such an equation the “mirror image” of equation (7). In this specific case, it reads as

$$\frac{c_1}{c_0} = (8.1)\cdot(8.2)\cdot(8.3)\cdot(8.4)\cdot(8.5)\cdot(8.6)\cdot(8.7)\cdot(8.8)\cdot(8.9)\cdot(8.10)\cdot(8.11) \qquad (8)$$

with

[5] Dietzenbacher and Los (1998) focused on this issue with respect to so-called additive decomposition forms. Their results carry over to multiplicative forms, such as pursued in this paper, as well.

$$(8.1) = \frac{1-\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_0^{\mathbf{IN}}\circ\left\{\mathbf{b}_0^{\mathbf{IN}}in_0\right\}+\mathbf{d}_0^{\mathbf{E}}\circ\left\{\mathbf{b}_0^{\mathbf{E}}e_0\right\}\right)}{1-\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_0^{\mathbf{IN}}\circ\left\{\mathbf{b}_0^{\mathbf{IN}}in_0\right\}+\mathbf{d}_0^{\mathbf{E}}\circ\left\{\mathbf{b}_0^{\mathbf{E}}e_0\right\}\right)}\cdot\frac{\mathbf{l}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_{\mathbf{0}}^{\mathbf{C}}\circ\mathbf{b}_0^{\mathbf{C}}\right)}{\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_{\mathbf{0}}^{\mathbf{C}}\circ\mathbf{b}_0^{\mathbf{C}}\right)}$$

$$(8.2) = \frac{1-\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_0^{\mathbf{IN}}\circ\left\{\mathbf{b}_0^{\mathbf{IN}}in_0\right\}+\mathbf{d}_0^{\mathbf{E}}\circ\left\{\mathbf{b}_0^{\mathbf{E}}e_0\right\}\right)}{1-\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_0^{\mathbf{IN}}\circ\left\{\mathbf{b}_0^{\mathbf{IN}}in_0\right\}+\mathbf{d}_0^{\mathbf{E}}\circ\left\{\mathbf{b}_0^{\mathbf{E}}e_0\right\}\right)}\cdot\frac{\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0\right)^{-1}\left(\mathbf{d}_{\mathbf{0}}^{\mathbf{C}}\circ\mathbf{b}_0^{\mathbf{C}}\right)}{\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_{\mathbf{0}}^{\mathbf{C}}\circ\mathbf{b}_0^{\mathbf{C}}\right)}$$

$$(8.3) = \frac{1-\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_0^{\mathbf{IN}}\circ\left\{\mathbf{b}_1^{\mathbf{IN}}in_0\right\}+\mathbf{d}_0^{\mathbf{E}}\circ\left\{\mathbf{b}_0^{\mathbf{E}}e_0\right\}\right)}{1-\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_0^{\mathbf{IN}}\circ\left\{\mathbf{b}_0^{\mathbf{IN}}in_0\right\}+\mathbf{d}_0^{\mathbf{E}}\circ\left\{\mathbf{b}_0^{\mathbf{E}}e_0\right\}\right)}$$

$$(8.4) = \frac{1-\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_0^{\mathbf{IN}}\circ\left\{\mathbf{b}_1^{\mathbf{IN}}in_0\right\}+\mathbf{d}_0^{\mathbf{E}}\circ\left\{\mathbf{b}_1^{\mathbf{E}}e_0\right\}\right)}{1-\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_0^{\mathbf{IN}}\circ\left\{\mathbf{b}_1^{\mathbf{IN}}in_0\right\}+\mathbf{d}_0^{\mathbf{E}}\circ\left\{\mathbf{b}_0^{\mathbf{E}}e_0\right\}\right)}$$

$$(8.5) = \frac{1-\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_0^{\mathbf{IN}}\circ\left\{\mathbf{b}_1^{\mathbf{IN}}in_0\right\}+\mathbf{d}_0^{\mathbf{E}}\circ\left\{\mathbf{b}_1^{\mathbf{E}}e_0\right\}\right)}{1-\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_0^{\mathbf{IN}}\circ\left\{\mathbf{b}_1^{\mathbf{IN}}in_0\right\}+\mathbf{d}_0^{\mathbf{E}}\circ\left\{\mathbf{b}_1^{\mathbf{E}}e_0\right\}\right)}\cdot\frac{\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_{\mathbf{0}}^{\mathbf{C}}\circ\mathbf{b}_0^{\mathbf{C}}\right)}{\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_{\mathbf{0}}^{\mathbf{C}}\circ\mathbf{b}_{\mathbf{1}}^{\mathbf{C}}\right)}$$

$$(8.6) = \frac{1-\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_0^{\mathbf{IN}}\circ\left\{\mathbf{b}_1^{\mathbf{IN}}in_0\right\}+\mathbf{d}_0^{\mathbf{E}}\circ\left\{\mathbf{b}_1^{\mathbf{E}}e_0\right\}\right)}{1-\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_0^{\mathbf{IN}}\circ\left\{\mathbf{b}_1^{\mathbf{IN}}in_0\right\}+\mathbf{d}_0^{\mathbf{E}}\circ\left\{\mathbf{b}_1^{\mathbf{E}}e_0\right\}\right)}\cdot\frac{\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_{\mathbf{0}}^{\mathbf{C}}\circ\mathbf{b}_{\mathbf{1}}^{\mathbf{C}}\right)}{\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_{\mathbf{0}}^{\mathbf{C}}\circ\mathbf{b}_{\mathbf{1}}^{\mathbf{C}}\right)}$$

$$(8.7) = \frac{1-\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_1^{\mathbf{IN}}\circ\left\{\mathbf{b}_1^{\mathbf{IN}}in_0\right\}+\mathbf{d}_0^{\mathbf{E}}\circ\left\{\mathbf{b}_1^{\mathbf{E}}e_0\right\}\right)}{1-\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_0^{\mathbf{IN}}\circ\left\{\mathbf{b}_1^{\mathbf{IN}}in_0\right\}+\mathbf{d}_0^{\mathbf{E}}\circ\left\{\mathbf{b}_1^{\mathbf{E}}e_0\right\}\right)}$$

$$(8.8) = \frac{1-\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_1^{\mathbf{IN}}\circ\left\{\mathbf{b}_1^{\mathbf{IN}}in_0\right\}+\mathbf{d}_1^{\mathbf{E}}\circ\left\{\mathbf{b}_1^{\mathbf{E}}e_0\right\}\right)}{1-\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_1^{\mathbf{IN}}\circ\left\{\mathbf{b}_1^{\mathbf{IN}}in_0\right\}+\mathbf{d}_0^{\mathbf{E}}\circ\left\{\mathbf{b}_1^{\mathbf{E}}e_0\right\}\right)}$$

$$(8.9) = \frac{1-\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_1^{\mathbf{IN}}\circ\left\{\mathbf{b}_1^{\mathbf{IN}}in_0\right\}+\mathbf{d}_1^{\mathbf{E}}\circ\left\{\mathbf{b}_1^{\mathbf{E}}e_0\right\}\right)}{1-\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_1^{\mathbf{IN}}\circ\left\{\mathbf{b}_1^{\mathbf{IN}}in_0\right\}+\mathbf{d}_1^{\mathbf{E}}\circ\left\{\mathbf{b}_1^{\mathbf{E}}e_0\right\}\right)}\cdot\frac{\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_{\mathbf{0}}^{\mathbf{C}}\circ\mathbf{b}_{\mathbf{1}}^{\mathbf{C}}\right)}{\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_1^{\mathbf{C}}\circ\mathbf{b}_{\mathbf{1}}^{\mathbf{C}}\right)}$$

$$(8.10) = \frac{1-\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_1^{\mathbf{IN}}\circ\left\{\mathbf{b}_1^{\mathbf{IN}}in_1\right\}+\mathbf{d}_1^{\mathbf{E}}\circ\left\{\mathbf{b}_1^{\mathbf{E}}e_0\right\}\right)}{1-\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_1^{\mathbf{IN}}\circ\left\{\mathbf{b}_1^{\mathbf{IN}}in_0\right\}+\mathbf{d}_1^{\mathbf{E}}\circ\left\{\mathbf{b}_1^{\mathbf{E}}e_0\right\}\right)}$$

$$(8.11) = \frac{1-\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_1^{\mathbf{IN}}\circ\left\{\mathbf{b}_1^{\mathbf{IN}}in_1\right\}+\mathbf{d}_1^{\mathbf{E}}\circ\left\{\mathbf{b}_1^{\mathbf{E}}e_1\right\}\right)}{1-\mathbf{l}_1'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1\right)^{-1}\left(\mathbf{d}_1^{\mathbf{IN}}\circ\left\{\mathbf{b}_1^{\mathbf{IN}}in_1\right\}+\mathbf{d}_1^{\mathbf{E}}\circ\left\{\mathbf{b}_1^{\mathbf{E}}e_0\right\}\right)}$$

Dietzenbacher and Los (1998) showed that many more possible equations are equally valid. In principle, one could compute results for each and every formula and present the average value for each factor as the contribution to the total effect. To save space, time and effort, we follow De Haan (2001), who found that averages of single pairs of mirror images are very close to the average over all possible decomposition forms. Hence, following Dietzenbacher *et al*. (2004), we compute Fisher indices (geometric averages) for pairs of factors in equations (7) and (8). To give an indication of the variation due to choice of indices, we will also report the results for the specific decomposition equations presented above.

3. Consumption Growth Accounting for the UK, 1979-1990

Information contained in the UK input-output tables for 1979 and 1990 contained in the OECD Input-Output Database (OECD, 1995) indicates that private consumption measured in 1980 pounds sterling rose by 30.2%. In the same period, government consumption grew even faster, by 68.2%. According to the 60-Industry Database (Groningen Growth and Development Centre, 2003) the total number of persons engaged in the UK economy grew by a mere 6.7%. In 1979, the average person employed generated 5928 pounds sterling of total consumption. In 1990, this had increased to 7813 pounds sterling, which implies an increase of 31.8%. Which factors contributed to this substantial increase in living standards? The methodology proposed in the previous section will be applied to answer this question.

3.1 Data issues

Two datasets were used. The data on labor inputs were taken from the 60-Industry Database maintained by the GGDC (Groningen Growth and Development Centre, 2003), described in O'Mahony and Van Ark (2003). The other data required could be retrieved from the OECD Input-Output Database (OECD, 1995). These datasets do not have a fully comparable industry classification. Therefore, some aggregations were required, which resulted into a 31-industry classification scheme. This classification can be found in Appendix A.

We chose to use "number of persons engaged" (series "EMP") as the indicator of labor inputs. This indicator includes employees as well as self-employed persons. In productivity studies, indicators that account for differences in hours worked are often preferred. In this case, the situation is different: consumption per person engaged is a better welfare indicator than consumption per hour worked.[6] Four input-output tables were used. Data on domestically produced input and outputs were taken from the tables titled "UKDIOK79" and "UKDIOK90". The tables titled "UKTIOK79" and "UKTIOK90" were used to obtain the required information on inputs and final demand delivered by foreign producers.

The elements of the vectors $\mathbf{d}^{\mathbf{C}}$ and $\mathbf{b}^{\mathbf{C}}$ were constructed by first adding the columns for private consumption and government consumption. This choice considers government consumption (supply of education, police, defence, etc.) as an addition to welfare. The alternative choice, including government consumption in the investment vector, would stress the idea that expenditures on infrastructure etc. represent important inputs into the production processes that cannot be attributed to sectors due to their public good character. The choice for either one alternative is not essential for the consumption growth accounting methodology as such, however.

Before equations (7) and (8) could be applied, one issue had to be solved. Due to reductions in stocks for a number of indusries, the investment columns contained a couple of sizeable negative entries, which would render the decomposition invalid (see footnote 4). To overcome this problem, we computed hypothetical intermediate input blocks, labor input levels and gross output levels, as if the "changes in stocks" column would have contained zeroes only and

[6] In a future version of the paper, we intend to include an analysis of consumption per hour worked as well, since it offers an interesting alternative view on the productivity of an economy. The required data are readily available in Groningen Growth and Development Centre (2003).

assuming that the intermediate input coefficients contained in **A**, the intermediate input trade coefficients contained in $\mathbf{D^A}$, and the labor input coefficients contained in **l** apply for this specific final demand category as well.[7]

3.2 Results

The results of the consumption growth decomposition are documented in Table 1. The two leftmost columns refer to the results obtained with equations (7) and (8), respectively. The Fisher-indices (i.e. the geometric means) for the respective effects are found in the rightmost column.

Table 1: Decomposition results

	Equation (7)	Equation (8)	Fisher index
(1) **l**-effect	1.733	1.487	1.605
(2) **A**-effect	0.783	0.796	0.789
(3) $\mathbf{b^{IN}}$-effect	1.001	1.002	1.002
(4) $\mathbf{b^{E}}$-effect	1.005	1.031	1.018
(5) $\mathbf{b^{C}}$-effect	0.969	0.975	0.972
(6) $\mathbf{D^{A}}$-effect	1.155	1.183	1.169
(7) $\mathbf{d^{IN}}$-effect	1.028	1.009	1.019
(8) $\mathbf{d^{E}}$-effect	1.007	1.001	1.004
(9) $\mathbf{d^{C}}$-effect	1.039	1.026	1.033
(10) *in*-effect	0.921	0.955	0.938
(11) *e*-effect	0.856	0.928	0.891
Product of (1)-(11)	1.296	1.296	1.296

From a methodological point of view, the sensitivity of results to the decomposition form as stressed by Dietzenbacher and Los (1998) already is also apparent in these results, too. Since this issue is not central to this paper, we will not discuss it at great length and base the discussion of the results on the Fisher indices.

The positive effect of labor input coefficient changes was very strong (it would have allowed for a 60% increase in consumption), as appears from the entry in the first row. In as many of 28 out of 31 industries, the labor input coefficient decreased between 1979 and 1990. In some industries, the decrease was very marked, for instance in the high-tech industries “office and computing machinery” and “radio, TV and communication equipent”. The effect of changes in intermediate input requirements was also substantial (-21%), but it reduced consumption. In 22 industries, the intermediate input requirements (aggregated over supplying industries) per unit of gross output increased. The most marked changes were found for the intermediate input use by

[7] An implication of this procedure is that the left hand side ratio of equation (6) takes on the value 1.296, whereas the actual ratio is 1.318. This is due to the fact that the actual change of stocks is not identical across industries. This downside of the approach could be avoided by distributing the changes in stocks of each industry proportionally over the intermediate deliveries by this industry.

“real estate and business services” and “other services”. Across industries, especially the input coefficients related to the use of “office and computing machinery” and “finance and insurance services” grew considerably.[8]

The effects of the composition of the final demand categories (effects (3)-(5)) are considerably smaller. Changes in the composition of consumption had the relatively strongest effect (-3%). Apparently, changes in tastes yielded a shift towards commodities that are relatively labor-intensive (i.e. they have high labor input coefficients). It should be noted that the sectors that produce these commodities do not necessarily have to be more labor-intensive than previously more popular consumption goods, but that labor intensity can also be higher in upstream industries.

The import effects were all positive, and was most pronounced for changes related to intermediate inputs. Apparently, the UK started to satisfy a larger part of its intermediate input demand through imports, thereby freeing up labor resources. Another explanation of the positive effects could be that the total level of imports did not increase much, but that the imports of the UK shifted from labor-extensive commodities to more labor-intensive goods. This would fit the theory that the production of labor-intensive good shifts to countries where wages are lower than in highly developed countries than the UK.

The production of investment goods and exported goods per person engaged increased. As a consequence, if only these changes would have taken place the consumption level per person engaged would have dropped significantly (by approximately 6% and 11%, respectively). Previously, we already mentioned that higher investment levels are necessary to support the use of more capital-intensive production technologies. Further, increasing exports are required to sustain increasing imports without running into current account problems. Such observations lead us to look also at the net effects of three categories of effects. These are documented in Table 2.

Table 2: Technology effects, taste effects and trade effects

	Equation (7)	Equation (8)	Fisher index
(a) technology effect	1.251	1.133	1.191
(b) taste effect	0.974	1.005	0.989
(c) trade effect	1.064	1.138	1.100
Product of (a)-(c)	1.296	1.296	1.296

We define the “technology effect” as the multiplication of effects (1), (2), (3) and (10). The idea is that it captures the joint effects of technology-related changes in labor requirements per unit of gross output, in use of intermediate inputs per unit of gross output, in the composition of investment demand and in the investment output per unit of labor. The net effect on the consumption level was strongly positive, since these technology-related changes allowed for an increase of nearly 20%.

[8] These industries stand out if unweighted averages over rows of **A** for 1979 and 1990 are compared.

The “taste effect” is defined as the multiplication of effects (4) and (5), the changes due to compositional changes in total consumption and exports.[9] These effects appear to be minor. Consumption per person engaged would have declined by just 1%.

The “trade effect” is obtained as the product of the remaining effects, (6)-(9) and (11). It relates to the effects of changes in import penetration in markets for intermediate, consumption, investment and export purposes. The net effect yielded an increase in consumption per person engaged of as much as 10%. This was mainly due to a deterioriation of the current account position (exports minus imports) expressed in 1980 prices, from +1.4 billions pound sterling in 1979 to -59.0 billions pound sterling in 1990.[10]

4. Conclusions

In this paper, we proposed a methodology to decompose consumption growth in an input-output framework. We offered an illustration for the case of the United Kingdom in the period 1979-1990. During this period consumption (in real terms) per person engaged grew by about 30%. The results indicate that if only changes in technology would have taken place, this growth would have amounted to approximately 20%. Consumption growth also benefited from a favorable change in foreign trade, which accounted for an additional 10%. Changes in the composition of consumption and exports (loosely called “taste effects”) had a negative, but significantly smaller effect. If only these effects would have occurred, consumption per person engaged would have declined by approximately 1%.

In our view, the methodology could be used for other types of questions as well. We will mention a few. First, we could identify the industries the labor productivity growth rates of which had an above-average impact on consumption growth. Such industries could be seen as “drivers of growth”. In a similar vein, it seems possible to single out commodities for which trade patterns have changed in a particularly favorable way. Second, the present analysis could also be used for “level accounting”. Differences between consumption levels of two countries or regions could be decomposed to quantify the effects that could account for them.

We think the approach could also be extended. Right now, we considered labor as one homogeneous factor, the supply of which determines how much can be consumed given production technologies, trade patterns and investment requirements. If more specific data would be available, one could also consider several types of labor and hypothesize about the type of labor the supply of which was binding. In a simlar vein, it would be interesting to see whether it is possible to produce decomposition formulae for the case in which the aggregate level of imports rather than labor is the binding constraint, due to current account pressures.

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[9] The inclusion of the export composition effect in the “taste effect” category is admittedly debatable, since we cannot distinguish between exports for consumption purposes and exports for investment or intermediate input purposes. If the latter two purposes would dominate, it would probably be preferable to include export composition effects in “technological effects”, although this category would then also include effects of technological change in foreign countries.

[10] Since the prices of UK exports rose much faster than the price of its imports, the actual trend in trade performance of the UK was much better than might be concluded from this finding.

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Appendix A

The table below contains the industry classification used in this study, and a concordance to the original input-output tables in OECD (1995) and labor input data in Groningen Growth and Development Centre (2003).

No.	Description	OECD (1995)	GGDC (2003)
1.	Agriculture, forestry and fishing	1	1 - 3
2.	Mining and quarrying	2	4
3.	Food, beverages and tobacco	3	5
4.	Textiles, apparel and leather	4	6 - 8
5.	Wood products and furniture	5	9
6.	Paper, paper products and printing	6	10, 11
7.	Chemicals	7, 8	13
8.	Petroleum and coal products	9	12
9.	Rubber and plastic products	10	14
10.	Non-metallic mineral products	11	15
11.	Basic metals	12, 13	16
12.	Metal products	14	17
13.	Non-electrical machinery	15	18
14.	Office and computing machinery	16	19
15.	Electrical apparatus, n.e.c.	17	20, 21
16.	Radio, TV and communication equipment	18	22 - 24
17.	Shipbuilding and repairing	19	28
18.	Other transport	20	30
19.	Motor vehicles	21	27
20.	Aircraft	22	29
21.	Professional goods	23	25, 26
22.	Other manufacturing	24	31
23.	Electricity, gas and water	25	32
24.	Construction	26	33
25.	Wholesale and retail trade	27	34 - 36
26.	Restaurants and hotels	28	37
27.	Transport and storage	29	38 - 41
28.	Communication	30	42
29.	Finance and insurance	31	43 - 45
30.	Real estate and business services	32	46 - 51
31.	Government, community, social and personal services	33, 34	52 - 55