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CONSUMPTION GROWTH ACCOUNTING

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The methodology in this paper combines an input–output structural decomposition approach with the supply-side perspective of mainstream growth accounting. In explaining the intertemporal change in consumption per worker, three sets of effects are distinguished. First, contributions due to several types of technological changes are considered. Second, effects caused by changes in international trade are discerned. Third, composition effects that reflect structural shifts in demand (including changes in tastes) are quantified. As an empirical illustration, we analyze the developments in the U.K. between 1979 and 1990.

1. INTRODUCTION

Recently, Eric Davidson published a book entitled "You Can't Eat GNP" (Davidson, 2000), in which he argues that economists should not focus solely on value added indicators to assess the performance of an economy. In this paper, we propose a methodology based on input–output economics that also starts from the viewpoint that GNP (or GDP) per capita does not capture all aspects of welfare. The production of increasing amounts of capital goods, and an upsurge in the output of exported products are reflected in growing value added figures, but do not necessarily imply more welfare. A glance at the Penn World Tables (Heston *et al.*, 2002) shows that such an approach is not only of academic interest. The shares of consumption in GDP vary considerably, both over time and across countries. In the U.K., for example, 70.3 percent of GDP was consumed in 1979, while this percentage increased to 75.1 in 1990.[1] In the same years, these proportions amounted to only 61.1 percent and 57.2 percent, respectively, in South Korea.

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[1]Values are reported for the Penn World Table variable "Consumption Share of RGDPL."

Weitzman (1976) showed that NNP, which adds net investment to consumption, can be considered as a proxy for the present discounted value of future consumption, if a few assumptions are taken for granted (such as perfect capital markets with perfect foresight). In view of Weitzman's statement that "economic activity has as its ultimate end consumption, not capital formation" (Weitzman, 1976, p. 156), we feel that long-run analyses of changes or differences in welfare based on value added-based indicators might usefully be complemented by studies that explicitly focus on current welfare (i.e. consumption). Of course, this does not mean that value-added based measures should not be used at all.

The methodology developed in this paper aims at quantifying the determinants of growth in consumption per worker, which we adopt as a more appropriate indicator of welfare.[2] It assesses the contributions of technological progress, changes in tastes and changing trade patterns to consumption growth. The methodology is linked to traditional growth accounting on the one hand and to accounting studies in input–output economics on the other.

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 viewed 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 tool and have been applied to a wide range of topics, 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, 2005; Jorgenson *et al.*, 2003; Timmer and van Ark, 2005).[3] 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; Timmer and Szirmai, 2000). In general, however, such studies cannot address the question of what factors drive structural change, because the industry-level input levels are considered as exogenous variables.

In contrast, input–output economics focuses on this specific issue of changes in the inter-industry structure. Typically, 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)[4] as the main determinants of endogenous output and employment levels. Output is thus a demand-driven variable. One of the empirical tools developed in this field is "structural decomposition

[2]Davidson (2000) argues that not only economic indicators, but also ecological issues and aspects of sustainability should be taken into consideration when analyzing welfare. These aspects have a mainly long-run character. Hence, their inclusion is beyond the scope of this paper.

[3]For a long time, 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.

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

analysis."[5] In its most basic form, it attributes intertemporal changes in output levels to contributions of changes in the demand levels for each of the industries and to changes in the input coefficients. The required data are contained in input–output tables. Seminal contributions to the literature are Feldman *et al.* (1987) who studied changes in U.S. industry outputs, and Wolff (1985, 1994) who analyzed changes in U.S. national total factor productivity levels.[6] Growth accounting studies and structural decomposition analyses thus attempt to gain insights into similar phenomena. In theory, they should be complementary, in the sense that they focus on different—not inherently conflicting—aspects of the growth process. In practice, however, growth accounting and structural decomposition analysis have not much (if at all) benefited from each other. In our view, this is mainly due to the opposite viewpoints with regard to the nature of the mechanisms that drive output (i.e. the supply-side versus the demand-driven perspective). As a consequence, the typical results of growth accounting studies and structural decomposition analyses are hard to reconcile. As an example, technological change is often found to be an important driver of value added change in growth accounts (especially for developed countries in which investment rates are relatively stable). In structural decomposition studies, however, value added growth is often ascribed to growth in consumption and investment demand, while the effects of technological change are only marginal.

The aim of the methodology outlined in this paper is thus twofold. First, we would like to reconcile both approaches. To this end, a new structural decomposition is proposed, which largely takes a supply-side perspective.[7] While labor supply is considered given, the input–output approach to structural change is preserved. Second, the use of detailed input–output tables allows for an analysis of consumption growth instead of GDP growth, which has been a common topic of study. 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 specify the contributions of the underlying determinants of the growth in total consumption per person engaged. Section 3 is devoted to an empirical illustration. We apply our consumption growth accounting framework to input–output tables and employment data for the United Kingdom in the period 1979–90. In this section, we will also explain that this application should be viewed as an illustration of the types of analysis that our framework allows for, rather than as a neat and careful dissection of the welfare growth performance of the U.K. Section 4 concludes.

[5]See Carter (1970) for an early contribution that has been instrumental in developing the technique.

[6]Dietzenbacher *et al.* (2000, 2004) extend parts of his approach to decompose, respectively, labor productivity growth rates in the European Union and changes in labor compensation's share in U.S. GDP. Recently, Wolff (2003) studied changes in the skills content of U.S. exports and imports by means of structural decomposition analysis. Wolff (2006) used structural decomposition analysis to quantify the role of technological change in the growth of the demand for information workers in the U.S. economy.

[7]This paper is not the first contribution to the literature that relates supply-side issues to input–output economics (see, for instance, ten Raa and Mohnen, 1994). Supply-driven decomposition analyses like the one proposed here have—to our knowledge—not been proposed so far, however.

2. Methodology

The starting point of our exposition is an input–output table with a square intermediate input block. The vector $\mathbf{x}$ with gross output levels, the matrix $\mathbf{A}$ with domestic input coefficients and the vector $\mathbf{f}$ with domestically produced final demands can be derived from such a table, which can either be of the industry-by-industry type or the commodity-by-commodity type.[8] We impose the well-known assumptions in input–output analysis that each industry produces a single commodity, and that each commodity can be produced by only one industry. Industries are thus assumed to correspond to commodities, which permits us to use the terms "output of industry *i*" and "production of commodity *i*" interchangeably, depending on convenience. Given these assumptions, the static open demand-driven input–output model is given by $\mathbf{x} = \mathbf{Ax} + \mathbf{b}^{\mathbf{F}}F$. The input coefficient a_{ij} gives the domestically produced intermediate inputs from industry i, required per unit of gross output in domestic industry j. The typical coefficient b_i^F represents the share of commodity i in aggregate final demand. If the parameters (i.e. the input coefficients and final demand shares) are known and the final demand level F is specified exogenously, the gross output levels are determined as $\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{b}^{\mathbf{F}}F$, where $\mathbf{I}$ denotes the identity matrix. Let the labor requirements per unit of output in each industry be given by the elements of the vector $\mathbf{h}$. Given the parameters in $\mathbf{A}$ and $\mathbf{h}$, the level of labor demand induced by an exogenously specified final demand level F is

$$(1) \qquad L^{dem} = \mathbf{h}'\mathbf{x} = \mathbf{h}'(\mathbf{I} - \mathbf{A})^{-1}\mathbf{b}^{\mathbf{F}}F.$$

The final demand vector $\mathbf{f} = \mathbf{b}^{\mathbf{F}}F$ consists of consumption demand (vector $\mathbf{c}$), investment demand ($\mathbf{v}$) and export demand ($\mathbf{e}$), so $\mathbf{f} = \mathbf{c} + \mathbf{v} + \mathbf{e}$.[9] Since the consumption level is the central variable in our analysis, it is convenient to recognize in this stage of the exposition already that part of consumption demand can be satisfied by imported goods and services.[10] Hence, we write the consumption demand as $\mathbf{c} = C(\mathbf{d}^{\mathbf{C}} \circ \mathbf{b}^{\mathbf{C}})$ where the scalar C denotes the level of total consumption, the vector $\mathbf{d}^{\mathbf{C}}$ indicates the commodity-specific shares of consumption that are domestically produced (i.e. not imported) and the vector $\mathbf{b}^{\mathbf{C}}$ consists of the commodity shares in total consumption.[11] For given parameters $\mathbf{A}$, $\mathbf{h}$, $\mathbf{d}^{\mathbf{C}}$ and $\mathbf{b}^{\mathbf{C}}$, and for exogenously specified $\mathbf{v}$, $\mathbf{e}$ and C the labor demand is given by

[8]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 worker terms. Bold lowercase symbols will be used to indicate vectors, and bold capitals to represent matrices. Primes indicate transposed vectors or matrices. Unless mentioned otherwise, dimensions of (column) vectors and matrices are $(n \times 1)$ and $(n \times n)$, respectively, with n representing the number of industries.

[9]Note that internationally adopted national accounting standards prescribe that input–output tables should be compiled according to the domestic concept (instead of the national concept). This implies that final demand contains the consumption of foreigners living in the country considered, but that consumption of citizens living abroad is not included in the consumption vector.

[10]We will introduce imports satisfying investment demand (and, although less important from an empirical point of view, export demand) later.

[11]The symbol $\circ$ indicates the Hadamard product of elementwise multiplication. That is, if $\mathbf{Q} = \mathbf{R} \circ \mathbf{S}$ we have $q_{ij} = r_{ij}s_{ij}$.

$$L^{dem} = \mathbf{h}'(\mathbf{I}-\mathbf{A})^{-1}\left(\mathbf{v}+\mathbf{e}+C\left(\mathbf{d}^{\mathbf{C}} \circ \mathbf{b}^{\mathbf{C}}\right)\right). \tag{2}$$

Thus a rise in the total consumption level C causes an increase in the total demand for labor, according to the static open demand-driven model.

Taking a supply-side perspective, however, (2) implies that we may calculate the consumption level that can be attained for a given level of labor supply. First, we derive the level of final demand (aggregated over industries) that can be produced by the available supply of labor L^{sup}. We do this by rearranging terms in (1):

$$F = \frac{L^{sup}}{\mathbf{h}'(\mathbf{I}-\mathbf{A})^{-1}\mathbf{b}^{\mathbf{F}}}. \tag{3}$$

Next, we should model how the share of consumption demand in total demand is determined. We consider consumption demand as a residual, in the sense that the economy first supplies exogenously determined demands for investment goods and exports. These are considered necessary to maintain current production possibilities in the future and to finance imports, respectively. The fraction of labor supply that remains is used for the production of consumption goods and the intermediate inputs required for their production. This modeling implies that the share of consumption in total final demand is not exogenously fixed. For given parameters $\mathbf{A}$, $\mathbf{h}$, $\mathbf{d}^{\mathbf{C}}$ and $\mathbf{b}^{\mathbf{C}}$, and for exogenously specified $\mathbf{v}$, $\mathbf{e}$ and labor supply L^{sup}, the total consumption level is obtained. In the same way as (3) is derived from (1) for the case of overall final demands, the terms of equation (2) can be rearranged for the case with three categories of final demands:

$$C = \frac{L^{sup}}{\mathbf{h}'(\mathbf{I}-\mathbf{A})^{-1}\left(\mathbf{d}^{\mathbf{C}} \circ \mathbf{b}^{\mathbf{C}}\right)} - \frac{\mathbf{h}'(\mathbf{I}-\mathbf{A})^{-1}(\mathbf{v}+\mathbf{e})}{\mathbf{h}'(\mathbf{I}-\mathbf{A})^{-1}\left(\mathbf{d}^{\mathbf{C}} \circ \mathbf{b}^{\mathbf{C}}\right)}. \tag{4}$$

Note that the numerators and denominators on the right hand side are scalars.

The first term on the right hand side of (4) indicates the level of consumption attainable if all labor resources would be devoted to the domestic production of consumption goods and the domestically manufactured intermediate inputs required to produce these. The higher the proportions of consumption demand met by imported goods (the smaller $\mathbf{d}^{\mathbf{C}}$), the lighter the burden on domestic labor resources and hence, the more consumption is feasible. The second term on the right hand side measures by what amount this consumption level is actually reduced due to the domestic production of investment goods and export goods, and the intermediate inputs required for these. They reduce the labor resources available for the production of consumption goods in the short run. In the long run, however, current production of investment and export goods is required to keep the labor demands per unit of output (i.e. the parameters $\mathbf{h}$) at stable or even lower levels in future periods (see the arguments put forward by Weitzman (1976) as briefly described in the introduction). If no capital goods are produced now, all future output would have to be produced by labor alone. In the same way, exports enable a country to buy commodities from abroad instead of producing them itself using its scarce labor.[12] Supposing that deliveries for consumption purposes can be viewed as a residual might seem most appropriate for centrally planned economies. In market economies, however, capacity-restricted firms also take investment demand (required by themselves and by customers to remain capable of producing and competing into the longer run) into consideration when deciding on the production levels of commodities for consumption purposes. Hence, we feel that our methodology is also relevant to analyze consumption growth in market economies.

The next step is to extend the model by introducing trade in intermediate inputs, investment goods and export goods. Recall that the input matrix $\mathbf{A}$ is based on domestic deliveries. An input matrix that represents the production structure takes all intermediate deliveries (i.e. including imported inputs) into account. Let us denote this matrix of technical input coefficients by $\mathbf{A}^{\mathbf{T}}$. Then, we may write $\mathbf{A} = \mathbf{D}^{\mathrm{A}} \circ \mathbf{A}^{\mathbf{T}}$, where $\mathbf{D}^{\mathrm{A}}$ gives the shares of demand that are produced domestically. In the same way, $\mathbf{v}$ denotes the demands for domestically produced investment goods. Using $\mathbf{v}^{\mathbf{T}}$ for the total demands we have $\mathbf{v} = \mathbf{d}^{\mathrm{V}} \circ \mathbf{v}^{\mathbf{T}}$, where the elements of $\mathbf{d}^{\mathrm{V}}$ again give the shares of the investment demands that are produced domestically. Further we may write $\mathbf{v}^{\mathbf{T}} = \mathbf{b}^{\mathrm{V}} \cdot V$ where V gives the national level of demand for investment goods and the elements of $\mathbf{b}^{\mathrm{V}}$ give demand for a specific good as a share of V. We thus have $\mathbf{v} = \mathbf{d}^{\mathrm{V}} \circ [\mathbf{b}^{\mathrm{V}} \cdot V]$. In the same way, we may write $\mathbf{e} = \mathbf{d}^{\mathrm{E}} \circ [\mathbf{b}^{\mathrm{E}} \cdot E]$. Substitution in (2) yields

$$(5)\quad C = \frac{L^{sup}}{\mathbf{h}'\left(\mathbf{I}-\mathbf{D}^{\mathrm{A}}\circ\mathbf{A}^{\mathbf{T}}\right)^{-1}\left(\mathbf{d}^{\mathrm{C}}\circ\mathbf{b}^{\mathrm{C}}\right)} - \frac{\mathbf{h}'\left(\mathbf{I}-\mathbf{D}^{\mathrm{A}}\circ\mathbf{A}^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}^{\mathrm{V}}\circ\left(\mathbf{b}^{\mathrm{V}}\cdot V\right)+\mathbf{d}^{\mathrm{E}}\circ\left(\mathbf{b}^{\mathrm{E}}\cdot E\right)\right]}{\mathbf{h}'\left(\mathbf{I}-\mathbf{D}^{\mathrm{A}}\circ\mathbf{A}^{\mathbf{T}}\right)^{-1}\left(\mathbf{d}^{\mathrm{C}}\circ\mathbf{b}^{\mathrm{C}}\right)}.$$

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 (5). To gain insight into the determinants of welfare change, it is useful to consider changes in consumption per worker, i.e. C/L^{sup}. Dividing both sides of (5) by L^{sup} and using $c \equiv C/L^{sup}$, $v \equiv V/L^{sup}$ and $e \equiv E/L^{sup}$ yields

$$(6)\quad c = \frac{1}{\mathbf{h}'\left(\mathbf{I}-\mathbf{D}^{\mathrm{A}}\circ\mathbf{A}^{\mathbf{T}}\right)^{-1}\left(\mathbf{d}^{\mathrm{C}}\circ\mathbf{b}^{\mathrm{C}}\right)} - \frac{\mathbf{h}'\left(\mathbf{I}-\mathbf{D}^{\mathrm{A}}\circ\mathbf{A}^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}^{\mathrm{V}}\circ\left(\mathbf{b}^{\mathrm{V}}\cdot v\right)+\mathbf{d}^{\mathrm{E}}\circ\left(\mathbf{b}^{\mathrm{E}}\cdot e\right)\right]}{\mathbf{h}'\left(\mathbf{I}-\mathbf{D}^{\mathrm{A}}\circ\mathbf{A}^{\mathbf{T}}\right)^{-1}\left(\mathbf{d}^{\mathrm{C}}\circ\mathbf{b}^{\mathrm{C}}\right)}.$$

The ratio of consumption per unit of labor in two periods (indicated by indices 0 and 1) can be written as:[13]

$$(7)\quad \frac{c_1}{c_0} = \frac{1-\mathbf{h}_1'\left(\mathbf{I}-\mathbf{D}_1^{\mathrm{A}}\circ\mathbf{A}_1^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}_1^{\mathrm{V}}\circ\left(\mathbf{b}_1^{\mathrm{V}}\cdot v_1\right)+\mathbf{d}_1^{\mathrm{E}}\circ\left(\mathbf{b}_1^{\mathrm{E}}\cdot e_1\right)\right]}{1-\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathrm{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}_0^{\mathrm{V}}\circ\left(\mathbf{b}_0^{\mathrm{V}}\cdot v_0\right)+\mathbf{d}_0^{\mathrm{E}}\circ\left(\mathbf{b}_0^{\mathrm{E}}\cdot e_0\right)\right]}\cdot\frac{\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathrm{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left(\mathbf{d}_0^{\mathrm{C}}\circ\mathbf{b}_0^{\mathrm{C}}\right)}{\mathbf{h}_1'\left(\mathbf{I}-\mathbf{D}_1^{\mathrm{A}}\circ\mathbf{A}_1^{\mathbf{T}}\right)^{-1}\left(\mathbf{d}_1^{\mathrm{C}}\circ\mathbf{b}_1^{\mathrm{C}}\right)}.$$

[12]Los (2001) included an equation similar to equation (4) as the short-run part of a dynamic input–output model for a closed economy. Thirlwall (1979) stressed the importance of generating sufficient export demand to meet increasing imports associated with a growing domestic economy.

[13]It should be mentioned that equation (7) only holds exactly if the investment vector does not contain negative entries.

Now, the methodology proposed by Dietzenbacher *et al.* (2000) can be used to express the right hand side of equation (7) as the product of 11 factors. Each of these terms gives the change in the consumption per unit of labor which would have been observed if only a single variable would have changed between period 0 and period 1. That is,

$$(8)\qquad = \frac{1-\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}_0^{\mathbf{V}}\circ\left(\mathbf{b}_0^{\mathbf{V}}\cdot v_1\right)+\mathbf{d}_0^{\mathbf{E}}\circ\left(\mathbf{b}_0^{\mathbf{E}}\cdot e_1\right)\right]}{1-\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}_0^{\mathbf{V}}\circ\left(\mathbf{b}_0^{\mathbf{V}}\cdot v_0\right)+\mathbf{d}_0^{\mathbf{E}}\circ\left(\mathbf{b}_0^{\mathbf{E}}\cdot e_1\right)\right]}$$

with

$$(8.1)\quad = \frac{1-\mathbf{h}_1'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}_1^{\mathbf{V}}\circ\left(\mathbf{b}_1^{\mathbf{V}}\cdot v_1\right)+\mathbf{d}_1^{\mathbf{E}}\circ\left(\mathbf{b}_1^{\mathbf{E}}\cdot e_1\right)\right]}{1-\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}_1^{\mathbf{V}}\circ\left(\mathbf{b}_1^{\mathbf{V}}\cdot v_1\right)+\mathbf{d}_1^{\mathbf{E}}\circ\left(\mathbf{b}_1^{\mathbf{E}}\cdot e_1\right)\right]}\cdot\frac{\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1^{\mathbf{T}}\right)^{-1}\left(\mathbf{d}_1^{\mathbf{C}}\circ\mathbf{b}_1^{\mathbf{C}}\right)}{\mathbf{h}_1'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1^{\mathbf{T}}\right)^{-1}\left(\mathbf{d}_1^{\mathbf{C}}\circ\mathbf{b}_1^{\mathbf{C}}\right)}$$

$$(8.2)\quad = \frac{1-\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}_1^{\mathbf{V}}\circ\left(\mathbf{b}_1^{\mathbf{V}}\cdot v_1\right)+\mathbf{d}_1^{\mathbf{E}}\circ\left(\mathbf{b}_1^{\mathbf{E}}\cdot e_1\right)\right]}{1-\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}_1^{\mathbf{V}}\circ\left(\mathbf{b}_1^{\mathbf{V}}\cdot v_1\right)+\mathbf{d}_1^{\mathbf{E}}\circ\left(\mathbf{b}_1^{\mathbf{E}}\cdot e_1\right)\right]}\cdot\frac{\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left(\mathbf{d}_1^{\mathbf{C}}\circ\mathbf{b}_1^{\mathbf{C}}\right)}{\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_1^{\mathbf{T}}\right)^{-1}\left(\mathbf{d}_1^{\mathbf{C}}\circ\mathbf{b}_1^{\mathbf{C}}\right)}$$

$$(8.3)\quad = \frac{1-\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}_1^{\mathbf{V}}\circ\left(\mathbf{b}_1^{\mathbf{V}}\cdot v_1\right)+\mathbf{d}_1^{\mathbf{E}}\circ\left(\mathbf{b}_1^{\mathbf{E}}\cdot e_1\right)\right]}{1-\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}_1^{\mathbf{V}}\circ\left(\mathbf{b}_0^{\mathbf{V}}\cdot v_1\right)+\mathbf{d}_1^{\mathbf{E}}\circ\left(\mathbf{b}_1^{\mathbf{E}}\cdot e_1\right)\right]}$$

$$(8.4)\quad = \frac{1-\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}_1^{\mathbf{V}}\circ\left(\mathbf{b}_0^{\mathbf{V}}\cdot v_1\right)+\mathbf{d}_1^{\mathbf{E}}\circ\left(\mathbf{b}_1^{\mathbf{E}}\cdot e_1\right)\right]}{1-\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}_1^{\mathbf{V}}\circ\left(\mathbf{b}_0^{\mathbf{V}}\cdot v_1\right)+\mathbf{d}_1^{\mathbf{E}}\circ\left(\mathbf{b}_0^{\mathbf{E}}\cdot e_1\right)\right]}$$

$$(8.5)\quad = \frac{\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left(\mathbf{d}_1^{\mathbf{C}}\circ\mathbf{b}_0^{\mathbf{C}}\right)}{\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left(\mathbf{d}_1^{\mathbf{C}}\circ\mathbf{b}_1^{\mathbf{C}}\right)}$$

$$(8.6)\quad = \frac{1-\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}_1^{\mathbf{V}}\circ\left(\mathbf{b}_0^{\mathbf{V}}\cdot v_1\right)+\mathbf{d}_1^{\mathbf{E}}\circ\left(\mathbf{b}_0^{\mathbf{E}}\cdot e_1\right)\right]}{1-\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}_1^{\mathbf{V}}\circ\left(\mathbf{b}_0^{\mathbf{V}}\cdot v_1\right)+\mathbf{d}_1^{\mathbf{E}}\circ\left(\mathbf{b}_0^{\mathbf{E}}\cdot e_1\right)\right]}\cdot\frac{\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left(\mathbf{d}_1^{\mathbf{C}}\circ\mathbf{b}_0^{\mathbf{C}}\right)}{\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_1^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left(\mathbf{d}_1^{\mathbf{C}}\circ\mathbf{b}_0^{\mathbf{C}}\right)}$$

$$(8.7)\quad = \frac{1-\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}_1^{\mathbf{V}}\circ\left(\mathbf{b}_0^{\mathbf{V}}\cdot v_1\right)+\mathbf{d}_1^{\mathbf{E}}\circ\left(\mathbf{b}_0^{\mathbf{E}}\cdot e_1\right)\right]}{1-\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}_0^{\mathbf{V}}\circ\left(\mathbf{b}_0^{\mathbf{V}}\cdot v_1\right)+\mathbf{d}_1^{\mathbf{E}}\circ\left(\mathbf{b}_0^{\mathbf{E}}\cdot e_1\right)\right]}$$

$$(8.8)\quad = \frac{1-\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}_0^{\mathbf{V}}\circ\left(\mathbf{b}_0^{\mathbf{V}}\cdot v_1\right)+\mathbf{d}_1^{\mathbf{E}}\circ\left(\mathbf{b}_0^{\mathbf{E}}\cdot e_1\right)\right]}{1-\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}_0^{\mathbf{V}}\circ\left(\mathbf{b}_0^{\mathbf{V}}\cdot v_1\right)+\mathbf{d}_0^{\mathbf{E}}\circ\left(\mathbf{b}_0^{\mathbf{E}}\cdot e_1\right)\right]}$$

$$(8.9)\quad = \frac{\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left(\mathbf{d}_0^{\mathbf{C}}\circ\mathbf{b}_0^{\mathbf{C}}\right)}{\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left(\mathbf{d}_1^{\mathbf{C}}\circ\mathbf{b}_0^{\mathbf{C}}\right)}$$

$$(8.10)\quad = \frac{1-\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}_0^{\mathbf{V}}\circ\left(\mathbf{b}_0^{\mathbf{V}}\cdot v_1\right)+\mathbf{d}_0^{\mathbf{E}}\circ\left(\mathbf{b}_0^{\mathbf{E}}\cdot e_1\right)\right]}{1-\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}_0^{\mathbf{V}}\circ\left(\mathbf{b}_0^{\mathbf{V}}\cdot v_0\right)+\mathbf{d}_0^{\mathbf{E}}\circ\left(\mathbf{b}_0^{\mathbf{E}}\cdot e_1\right)\right]}$$

$$(8.11)\quad = \frac{1-\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}_0^{\mathbf{V}}\circ\left(\mathbf{b}_0^{\mathbf{V}}\cdot v_0\right)+\mathbf{d}_0^{\mathbf{E}}\circ\left(\mathbf{b}_0^{\mathbf{E}}\cdot e_1\right)\right]}{1-\mathbf{h}_0'\left(\mathbf{I}-\mathbf{D}_0^{\mathbf{A}}\circ\mathbf{A}_0^{\mathbf{T}}\right)^{-1}\left[\mathbf{d}_0^{\mathbf{V}}\circ\left(\mathbf{b}_0^{\mathbf{V}}\cdot v_0\right)+\mathbf{d}_0^{\mathbf{E}}\circ\left(\mathbf{b}_0^{\mathbf{E}}\cdot e_0\right)\right]}$$

The factors (8.1) and (8.2) represent the contribution of changes in the production technologies to the aggregate change in consumption per worker. Factor (8.1) gives the hypothetical rate of growth of consumption per worker if only the labor input coefficients per unit of gross output (i.e. vector $\mathbf{h}$) would have changed. In a similar vein, (8.2) gives the change that would have occurred if only the technical intermediate input coefficients (i.e. matrix $\mathbf{A}^{\mathbf{T}}$) would have changed and everything else would have remained constant.

Factors (8.3)–(8.5) reflect changes in the total consumption per worker attainable due to changes of the commodity shares in investment demand ($\mathbf{b}^{\mathbf{V}}$), export demand ($\mathbf{b}^{\mathbf{E}}$) and consumption demand ($\mathbf{b}^{\mathbf{C}}$), respectively. These contributions might be substantial. For example, if demand shifts from commodities that require relatively little labor input and relatively few labor-intensive intermediate inputs in their production to products that are produced in a much more labor-intensive way (either directly or indirectly), consumption per worker may be expected to decline.

Factors (8.6)–(8.9) 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 would 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 (8.8) measures the effects of changes in the share of transit flows in total exports. Because nearly all exports are produced domestically in most countries, this ratio will generally yield a value very close to 1.0.

Finally, factors (8.10) and (8.11) indicate by how much consumption per worker would have changed if only the total national investment demand per unit of labor and total national export demand per unit of labor would have changed. The former factor is partly due to technological change, since labor-saving innovations will increase the capital–labor ratio and therefore raise investment demand per worker. An alternative decomposition analysis could include the *share* of income spent on investment as a determinant of consumption growth. In our setup, changes in the *level* of investment demand (scaled by employment) reflect that consumption growth is often constrained due to increased demand for capital goods.[14]

[14]An option not pursued in this paper is to study effects of changes concerning single industries or specific clusters of industries. One could split each of the factors (8.1)–(8.9) into two or more factors. For example, (8.1) could be decomposed into a factor indicating the effects of changes in labor input coefficients in agricultural industries (everything else equal) and a factor indicating the effects of changes in labor input coefficients in the remaining industries (everything else equal).

Changing international trade patterns enter the accounting framework in two ways. First, the division of labor between the country under consideration and its trading partners might yield a labor saving effect. This would happen if the country exports relatively more labor-extensive commodities and imports more relatively labor-intensive goods. The effect of the changes in the basket of exports is captured by (8.4), while—as mentioned before—changes in the composition of imports are reflected in (8.6)–(8.9). In many cases, however, such effects of changing exports and imports compositions will also have implications for the exports and imports volumes. Countries cannot import to unlimited extents without exporting. The ratio of imports to exports is not necessarily unity, however. As was stressed by McCombie and Thirlwall (1994), countries that prove able to attract a considerable amount of foreign capital might run current account deficits for a long time. Second, changes in these abilities imply changes in the volume of exports required to gain access to a given volume of imports. Changes in a country's terms of trade are another very important determinant of changes in the volume of exports a country should generate. If exports get more expensive and/or imports become relatively cheap, a lower volume of exports suffices to maintain a given current account situation. Equation (8) cannot fully disentangle the above-mentioned composition and level effects. It is important to note that our accounting framework does not aim to explain *why* trade patterns change (terms of trade effects, for instance, would require modeling of relative prices), but to indicate *how much* changes in trade patterns contributed to consumption growth.

It is well known that structural decompositions are not unique. One could, for example, also opt for the so-called "mirror image" (de Haan, 2001). For example, (8.2) gives the effect of changes in $\mathbf{A}^{\mathbf{T}}$. The mirror image of (8.2) would be obtained by replacing indices 1 by 0, and vice versa, for all variables except $\mathbf{A}^{\mathbf{T}}$. The same procedure can be applied to each of the other 10 factors. Dietzenbacher and Los (1998) showed that many more possible equations are equally valid. They also found that the magnitudes of the contributions of the sources of growth as found in structural decomposition analyses may heavily depend on the specific decomposition equation chosen.[15] To handle this non-uniqueness issue, they suggest computing the results for each and every formula and present the average value for each factor as the contribution to the total effect. De Haan (2001) shows that space, time and effort can be saved, because averages of single pairs of mirror images appear to be 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 obtained from equation (8) and its mirror image. To give an indication of the variation due to choice of indices, we will also report the results for each of the two specific decomposition equations separately.

3. Consumption Growth Accounting for the U.K., 1979–90

Private consumption in the U.K. (measured in 1980 pounds sterling) rose by 30.2 percent between 1979 and 1990. In the same period, government consumption

[15]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.

grew even faster, by 68.2 percent. The total number of persons engaged in the U.K. economy increased by a mere 6.7 percent. In 1979, the average person employed generated £5,928 of total consumption. In 1990, this had increased to £7,813, which implies an increase of 31.8 percent. Which factors have contributed to this substantial increase in living standards? The methodology proposed in the previous section will be applied to answer this question. It should be emphasized, however, that our choice for the U.K. and the period 1979–90 was merely inspired by the fact that a dataset containing the variables of interest was readily available. As we will explain, an analysis aimed at explaining consumption growth for a country or region should use the most detailed data available. We will hint at a few aspects of our data that could have been improved upon if explaining consumption growth in the United Kingdom between 1979 and 1990 (rather than introducing a new analytical methodology) would have been the main goal of this paper.

3.1. *Data Issues*

Two datasets were used. The U.K. industry-by-industry input–output tables for 1979 and 1990 (expressed in 1980 pounds sterling, at producers' prices) are contained in the OECD input–output database (OECD, 1995).[16] The data on labor inputs were taken from the 60-Industry Database maintained by the GGDC (Groningen Growth and Development Centre, 2004), described in O'Mahony and van Ark (2003). Because these datasets do not have a fully comparable industry classification, some aggregation was required. This resulted in a 31-industry classification scheme, which can be found in the Appendix.

We chose to use "the number of persons engaged" (series "EMP") as our indicator of labor inputs. This indicator includes employees as well as self-employed persons. Four input–output tables have been used. Data on domestically produced inputs and outputs were taken from the tables entitled "UKDIOK79" and "UKDIOK90." The tables entitled "UKTIOK79" and "UKTIOK90" were used to obtain the required information on intermediate inputs and final demands delivered by foreign producers.

The elements of the vectors $\mathbf{d}^C$ and $\mathbf{b}^C$ were constructed by first adding the columns for private consumption and government consumption. This means that we consider government consumption (supply of education, police, defense, etc) as an addition to welfare. Alternatively, we could have chosen to include government consumption in the investment vector, to treat it as a separate category or to split it between consumption and investments (e.g. if additional information would have been available). Clearly, any of these choices affects the interpretation of the

[16]Input–output tables in constant prices are required for this type of analysis, otherwise (industry-specific) inflation rates would have a detrimental effect on the economic sensibility of the results. Nowadays, under the ESA95 regime, most national statistical institutes only publish tables in current prices and in prices of the previous year. For many analytical purposes (including studies of long-run growth) time series of tables expressed in common prices are indispensable, however. The OECD dataset, consisting of industry-by-industry tables, is a rather rare example of this species. OECD (2000a, 2000b) offer information on the compilation of the tables. It should be noted, however, that these documents are silent on the way in which family expenditure survey data have been aligned with the industry classification (see Shoven and Whalley, 1992, pp. 106–15, for a discussion of this type of problems).

TABLE 1

DECOMPOSITION RESULTS

	Equation (8)	Mirror Image	Fisher Index
(1) **h**-effect	1.733	1.487	1.605
(2) $\mathbf{A}^{\mathbf{T}}$-effect	0.783	0.796	0.789
(3) $\mathbf{b}^{\mathrm{V}}$-effect	1.001	1.002	1.002
(4) $\mathbf{b}^{\mathrm{E}}$-effect	1.005	1.031	1.018
(5) $\mathbf{b}^{\mathrm{C}}$-effect	0.969	0.975	0.972
(6) $\mathbf{D}^{\mathrm{A}}$-effect	1.155	1.183	1.169
(7) $\mathbf{d}^{\mathrm{V}}$-effect	1.028	1.009	1.019
(8) $\mathbf{d}^{\mathrm{E}}$-effect	1.007	1.001	1.004
(9) $\mathbf{d}^{\mathrm{C}}$-effect	1.039	1.026	1.033
(10) v-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

Note: The reported **h**-effects are obtained from equation (8.1) and its mirror image, the $\mathbf{A}^{\mathbf{T}}$-effects from equation (8.2) and its mirror image, etc.

results. For example, including government consumption with investments might follow from the hypothesis that, due to their public good character, expenditures on infrastructure etc represent important inputs into the production processes that cannot be attributed to industries. In any case, the particular choice for one of the alternatives is not essential for the consumption growth accounting methodology as such.

Before equation (8) and its mirror image could be applied, one issue had to be solved. Due to reductions in stocks for a number of industries, the investment columns contained a couple of sizeable negative entries, which would render the decomposition invalid (see footnote 13). To overcome this problem, we computed hypothetical intermediate input levels, labor input levels and gross output levels, as if the "changes in stocks" column would have contained zeroes only. In doing so, it was assumed that the intermediate input coefficients ($\mathbf{A}^{\mathbf{T}}$), the intermediate input trade coefficients ($\mathbf{D}^{\mathrm{A}}$), and the labor input coefficients (**h**) also applied to this hypothetical case.[17]

3.2. *Results*

The results of the consumption growth decomposition are presented in Table 1. The findings obtained with equation (8) and its mirror image are listed separately; the Fisher indices are obtained as the geometric mean of the respective effects.

From a methodological point of view, the sensitivity of the results with respect to the decomposition form (i.e. either equation (8) or its mirror image) as stressed by Dietzenbacher and Los (1998) is apparent. Note, however, that the "direction"

[17]An implication of this procedure is that the left hand side ratio of equation (8) 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 might be avoided, for example, by distributing the changes in stocks of each industry proportionally over the intermediate deliveries by this industry.

of the effect is always the same. That is, both equation (8) and its mirror image report that the change in some factor is responsible for an increase (or decrease) in the consumption per person engaged. Only the size of the increase (respectively decrease) differs between the two decomposition forms. Since the issue of sensitivity is not central to this paper, we will restrict the discussion to the results of the Fisher indices.

The positive effect of labor input coefficient (**h**) changes was very strong (it would have allowed for a 60 percent increase in consumption), as appears from the entry in the first row. In no less than 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 equipment." The effect of changes in the technical intermediate input requirements was also substantial and would have reduced consumption by 21 percent. In 22 industries, the total intermediate input requirements—aggregated over supplying industries—per unit of gross output (i.e. the column sums of $\mathbf{A}^T$) increased. The most marked changes were found for the intermediate input use by "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.[18]

The effects of the composition of the final demand categories (the **b**-effects (3)–(5) in Table 1) are considerably smaller. Changes in the composition of consumption had the strongest effect (–3 percent) of these three. Various developments could have caused this composition to change over the period 1979–90. Income elasticities may well have differed across commodities (Engel curves), relative price changes may have affected the consumption shares and changes in tastes may well have changed "autonomously," for example, due to fads.[19] Apparently, "changes in tastes" (the catch-all term we will use) yielded a shift towards commodities that are relatively labor-intensive. This higher labor-intensity may be caused directly (meaning that the industry producing such a commodity has a high labor input coefficient) and/or indirectly (meaning that the production of such a commodity requires a large amount of intermediate inputs that are produced in upstream industries with high labor coefficients). The changes in the composition of the exports had an opposite effect (2 percent), reflecting a shift towards relatively less labor-intensive commodities.

The import effects (due to changes in $\mathbf{D}^A$, $\mathbf{d}^V$, $\mathbf{d}^E$, and $\mathbf{d}^C$) were all positive, and were most pronounced for changes related to intermediate inputs. Also in this case, we may distinguish two forces at work. On the one hand, the positive import effects have partly been caused by a decrease in the share (of intermediate inputs)

[18]These industries stand out if simple averages for the rows of **A** for 1979 and 1990 are compared.

[19]Shoven and Whalley (1992, Ch. 5) explicitly specify consumer classes by introducing income ranges. Alcala *et al.* (1999) examine changes in private consumption patterns due to changes in the relative importance of several consumption purpose categories, introducing the "consumption converter." Increases in the relative importance of a purpose category can be due to either income effects or autonomous changes. Duchin (1998) suggests to discern consumer classes based on "lifestyles" rather than on income ranges. We acknowledge the variety of reasons behind changes in the composition of a nation's aggregate consumption vector. For ease of exposition, we will indicate its contribution to the change in consumption level as the effect of changes in tastes.

TABLE 2

Technology Effects, Taste Effects and Trade Effects

	Equation (8)	Mirror Image	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

(a): Product of effects (1), (2), (3) and (10) in equation (8) and Table 1.

(b): Product of effects (4) and (5).

(c): Product of effects (6), (7), (8), (9) and (11).

that was produced domestically (i.e. $\mathbf{D}^A$). The U.K. started to satisfy a larger part of its intermediate input demand through imports, thereby freeing up labor resources for the production of consumption goods. On the other hand, a shift in the U.K. imports from labor-extensive commodities to more labor-intensive goods (which may occur even if the total level of imports does not increase) has contributed to the positive import effects. This fits in with the theory that the production of labor-intensive goods shifts to countries where wages are lower than in highly developed countries such as the U.K.

The production of investment goods (v) and exported goods (e) 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 percent and 11 percent, respectively). These findings are in line with our earlier observations. 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 indicate that several factors are usually part of the same economic "story." Therefore Table 2 presents the net effects of three categories of effects.

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 ($\mathbf{h}$), in the use of intermediate inputs per unit of gross output ($\mathbf{A}^T$), in the composition of investment demand ($\mathbf{b}^V$) and in the total investment per unit of labor (v). The net effect on the consumption level was strongly positive, since these technology-related changes allowed for an increase of nearly 20 percent.

The "taste effect" is defined as the multiplication of effects (4) and (5), which are the changes due to compositional changes in total consumption ($\mathbf{b}^C$) and total exports ($\mathbf{b}^E$).[20] These effects appear to be minor. Consumption per person engaged would have declined by just 1 percent.

[20]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.

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 percent. This was mainly due to a deterioration of the current account position (exports minus imports), from £+1.4 billion in 1979 to £–59.0 billion in 1990. Note, however, that these numbers are expressed in constant, 1980 prices. Since the prices of U.K. exports rose much faster than the price of its imports, the actual trend in trade performance of the U.K. was much better than might be concluded from this finding.[21] A detailed analysis of the underlying trends that yielded this favorable terms-of-trade effect cannot be carried out using our analytical framework, but price changes in natural resources and changing intra-industry trade patterns (developing countries specializing in "low value added activities" in the value chain and developed countries like the U.K. focusing on activities with high value added) are often held responsible for effects like this. Finally, it should be mentioned that deterioration of the current account expressed in current prices is not necessarily a problem, as long as the country proves able to attract sufficient capital flows from abroad.

3.3. *Reflections*

As mentioned before, the analysis for the U.K. 1979–90 should be viewed as an illustration of the type of issues that can be addressed by means of the methodology we propose, rather than as a neat analysis of consumption growth in the country and period mentioned. Nevertheless, it might be insightful to dwell somewhat on the limitations of the method and the role data availability and changing economic circumstances could play. Such observations could sharpen our view on the possibilities and impossibilities for analyses using the framework introduced here.

First, it is important to recall that we use input–output tables and compute input coefficients, which give the requirements of intermediate inputs and labor per unit of gross output, for each industry. The implicit assumption is that both outputs and production processes are perfectly identical across the firms of which such an industry is comprised. In reality, heterogeneity abounds. Hence, it is inevitable that changes in commodity-mix and/or production process mix within industries are incorporated in what we call "technology effects." This problem will be alleviated somewhat if input–output tables with a very detailed industry classification can be used. However, phenomena like varying returns to scale will often be present and yield production process heterogeneity. In some cases, constructors of Social Accounting Matrices discern "subindustries," which consist of an industry's firms within specific size ranges or firms within specific capital intensity

[21]The tables expressed in current prices in OECD (1995), "UKTIOC79" and "UKTIOC90," show that the current account position of the U.K. worsened from £–0.8 billion to £–25.5 billion, which implies that roughly half of the change in terms of constant prices can be attributed to a favorable terms-of-trade effect. In their contribution to the traditional growth accounting literature, Diewert and Morrison show that such "an increase in the price of exports relative to imports has an effect that is similar to an increase in total factor productivity" (Diewert and Morrison, 1986, p. 659). Our result regarding the "trade effect" is in line with this observation.

ranges. If such detailed information is available, more narrowly defined "technology effects" can be determined apart from "within industry mix" effects. The latter could be partly due to changes in relative prices, of which we abstract in assuming Leontief fixed coefficients technologies (see, e.g. Pyatt and Round, 1979, for discussion).

Second, we considered consumption per worker as our measure of productivity of the economy's production process. It is also possible to adopt different perspectives. From a welfare perspective, changes in consumption per capita might be preferred as the effect to be studied. If we denote the population size by N, consumption per capita equals $C/N = (C/L)(L/N)$, where L/N indicates the proportion of workers in the population. Decomposing the change in consumption per capita yields the same 11 factors as listed in equation (8) and one additional factor, i.e. the change in the proportion of the population that is employed. The underlying assumption would be that changes in this proportion are driven by supply-side factors, such as unemployment benefits and skill levels. From a productivity perspective, it might also be interesting to look at consumption per hour worked. As is well known (see, e.g. O'Mahony and van Ark, 2003) average working hours per job vary considerably across countries and over time. Especially in economies characterized by a shift from manufacturing to services activity (such as the U.K. studied above), the results for consumption per hour worked might well differ from those for consumption per worker. For instance, a relatively large number of female workers became employed in services, working shorter hours per week. *Ceteris paribus*, this must have yielded productivity reductions in terms of consumption per worker, while consumption per hour would have remained equal.

Finally, the empirical illustration suffers from many statistical problems common to productivity studies that consider economies as composed of various either broadly or narrowly defined industries. Virtually all studies using two or more input–output tables suffer from these problems, too. Reclassifications of industries by national statistical agencies, different treatments of secondary production (particularly important in eras of widespread outsourcing of non-core business) and so on are often difficult to deal with in a satisfactory manner. Nevertheless, we feel that careful consideration of such problems by statistical agencies and researchers would render analyses outlined above for a specific country and a specific period useful, without claiming any general validity of the results for other countries or other time periods.

4. Conclusions

In this paper, we proposed a methodology to decompose consumption growth in an input–output framework. Most studies based on input–output tables use a demand-driven model. That is, the levels of final demand and the structure of input requirements are assumed to determine how much (perfectly elastically available) labor is actually demanded. In contrast, the opposite is assumed in the framework proposed in this paper. Taking a supply-side perspective, labor supply is assumed to be given. Together with the input requirements structure, it determines what levels of final demand can be satisfied. Such a supply-driven approach is more in line with popular growth accounting methodologies inspired by Abramovitz (1956) and Solow (1957). Furthermore, it enables us to decompose growth of consumption instead of GDP. We do so by assuming that investment demand and export demand have to be met first, in order to be able to continue producing with modern production processes and to continue importing without running into balance of payments problems, respectively. The remaining labor resources are then used to produce goods for consumption purposes and the intermediate inputs required for them.

We offered an illustration for the case of the United Kingdom in the period 1979–90. During this period, consumption (in real terms) per person engaged grew by about 30 percent. The results indicate that if only changes in technology would have taken place, this growth would have amounted to approximately 20 percent. Consumption growth also benefited from a favorable change in foreign trade, which accounted for an additional 10 percent. 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 percent.

In our view, the methodology may be used for other types of questions as well. First, one could identify the industries in which the labor productivity growth rates have had an above-average impact on consumption growth. Such industries may be characterized as "drivers of growth." In a subsequent stage, more traditional industry-level growth accounting techniques could be applied to investigate whether capital accumulation or TFP-growth can be held responsible for their extraordinary impact. 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 may also be used for "level accounting." In that case, differences between consumption levels of two countries or regions are decomposed to quantify the effects that could account for them.

Our approach may also be extended in several ways. First, in the present paper, we have considered labor as a single homogeneous factor, the supply of which determines how much can be consumed given production technologies, trade patterns and investment requirements. If more specific data were available, one could consider several types of labor and hypothesize about the type of labor for which supply has been binding. Second, decomposition formulae may be derived for the case in which the aggregate level of imports (rather than labor) is the binding constraint, e.g. due to current account pressures.

Appendix

Table A1 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 the Groningen Growth and Development Centre (2004).

TABLE A1
Industry Classification

No.	Description	OECD (1995)	GGDC (2004)
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

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