On Concepts and Measures of Changes in Productivity — A reformulation*

Nadia Garbellini†
and
Ariel Luis Wirkierman‡

April 17, 2012

Abstract There exists a vast literature on the measurement of productivity changes, reflecting a wide range of theoretical approaches to economic analysis. The present paper departs from Pasinetti's (1959) critique to Solow's (1957) seminal paper, and advances a novel reformulation of Pasinetti's (1959) original physical productivity measures in an Input-Output framework, considering the reproducible character of intermediate commodities and fixed capital goods.

By reclassifying industry magnitudes in terms of vertically (hyper-) integrated sectors, it is possible to change the unit of analysis and devise sectoral measures of total labour productivity changes, which account for the input requirements of all supporting industries participating in the production of each final commodity. Moreover, by measuring composite capital goods in terms of units of productive capacity we distinguish the analysis of technical change from the pace of accumulation.

The correspondence between empirical magnitudes and theoretical categories of Pasinetti (1973, 1988) is established by departing from a set of square commodity × activity Supply-Use Tables (SUT) and associated capital coefficient matrices, acknowledging the difference between depreciation, retirements and replacements of fixed capital in observed given structures.

In order to empirically quantify the dynamics of employment and technical change, the productivity measures derived have been applied to the case of Italy during the period 1999-2007.

Complementarily, in the light of the 'yeast vs. mushrooms' debate initiated by Harberger (1998), the pattern of concentration of disaggregated total labour

*Paper prepared for the *20th. International Input-Output Conference*, Bratislava (Slovakia), June 26-29, 2012. Draft version, please do not quote without permission of the authors.

†Facoltà di Economia, Università degli Studi di Pavia (Via San Felice, 7, 27100, Pavia, Italy), `nadia.garbellini@unipv.it`

‡Facoltà di Economia, Università Cattolica del Sacro Cuore (Via Necchi, 5, 20123, Milano, Italy), `ariwirkierman@gmail.com`

productivity changes by subsystem is compared to traditional Input-Output TFP growth measures by industry, allowing to uncover methodological differences implied by each approach.

Keywords Labour Productivity, Vertically (hyper-) integrated sectors, Total Factor Productivity, Input-Output Analysis.

JEL classification C67, B51, D24, O14, O41

> "In this day of rationally designed econometric studies and super-input-output tables, it takes something more than the usual "willing suspension of disbelief" to talk seriously of the aggregate production function" (Solow 1957, p. 312)

> "In a production system, saving labour is the ultimate meaning of technical progress" (Pasinetti 1981, p. 207)

1 Concepts and measures of changes in productivity in historical perspective

The literature concerning technical progress and (changes in) productivity measurement is very vast and long-standing, proceeding from many, and very different, theoretical and empirical approaches. A comprehensive review of such a literature is out of the scope of the present paper; however, it is worth devoting some time to one specific debate which is exactly the starting point and the inspiration of this paper.

At the end of the 1950s, Robert Solow published his famous paper 'Technical Change and the Aggregate Production Function' (1957), in which he described "an elementary way of segregating variations in output per head due to technical change from those due to the availability of capital per head" (Solow 1957, p. 312). The paper was an attempt to make an explicit distinction between shifts in the aggregate production function and movements along it, also providing an empirical application for the US economy between 1909 and 1949.

Based on Hicks' classification, Solow considered "[s]hifts in the production function [...] as neutral if they leave marginal rates of substitution untouched [...], simply increas[ing] or decreas[ing] the output attainable from given inputs" (Solow 1957, p. 312). His conclusions were that in the period considered shifts in the production function had been almost neutral, with an acceleration of technical change after 1929. More precisely, over the whole period output per man hours doubled, with 12.5% of this increase due to a higher capital-labour ratio and 87.5% due to 'technical change' — the well known Solow's residual.

Pasinetti's comment on Solow's argument came two years later in the *Review of Economics and Statistics* (Pasinetti 1959, 'On Concepts and Measures of Changes in Productivity'), criticising Solow's attempt to evaluate technical change "and to introduce capital into the picture by making use of theoretical notions like the production function", since "these attempts [...] have neglected an important characteristic of capital — that it is reproducible and that its process of production is also subject to technical change" (Pasinetti 1959, p. 270).

But Pasinetti did not limit himself to criticise Solow's theoretical approach, clearly in sharp contrast with his own. He also put forward a methodological proposal for dealing with the issue of technical change in a more complete and consistent way, and then implemented it for the case of the US economy between 1929 and 1950 — i.e. the period in which Solow recognised an acceleration of technical progress accompanied by an increase in capital intensity.

More specifically, Pasinetti considered not only the process of producing final (consumption) commodities, but also that of producing the corresponding productive capacity. In this way, he derived a simple index of the direction of technical change by computing the variation in the ratio of output per man hours in the consumption goods sector to the hypothetical output per man hours that would be necessary to reproduce the corresponding productive capacity. When such a ratio is constant through time technical progress is neutral in the sense of Harrod.[1] On the contrary, changes in such a ratio reflect capital or labour saving technical progress, according to their sign.

We can notice that Pasinetti adopted Harrod's — and not Hicks' as Solow did — classification of technical progress. As he pointed out, the latter criterion "only conveys the information that technical progress takes place exclusively in the capital goods producing sector. [...] The richest [...] [criterion] for 'neutrality' — in terms of information content — seems therefore to be the first one [...] which conveys information on the effects of technical progress on capital-intensity, i.e. on the proportion between the labour which must be locked-up in the means of production and the labour which is currently required" (Pasinetti 1981, p. 214).

Moreover, Solow identified capital intensity with the capital-labour ratio, which Pasinetti calls 'degree of mechanisation', while for Pasinetti capital intensity is given by the capital-net output ratio. In fact, when this distinction is recognised:

> Solow's conclusions are therefore ambiguous and contradictory. What one can simply say is that the technological change that took place in the U.S. economy, from 1909 to 1949, was accompanied by an increase in the degree of mechanisation (and not in capital intensity), and by a decrease (not an increase!) in capital intensity.
>
> (Pasinetti 1981, p. 184n)

Solow's reply and Pasinetti's rejoinder appeared on the very same issue of the *Review of Economics and Statistics*.

[1] See the discussion in Harrod (1973, pp. 52-57).

Solow argued that Pasinetti's method cannot be accurate in general, the only exception being the irrelevant case "when Q is produced by K and L in fixed proportions, and no one ever wastes any K or L" (Pasinetti 1959, p. 283, Solow's Comment). Moreover, he pointed out that Pasinetti's "doubling the number of the commodities in the model increases its realism by 100 per cent [...] [I]f there are really 1,000 commodities worth distinguishing we only decrease the unrealism by about one-tenth of one per cent" (Pasinetti 1959, p. 283, Solow's Comment).

However, in explicitly considering productive capacity, Pasinetti is not going from a one- to a two-sector model, but rather accounting for the fact that technical change takes place also in the production of capital goods, and that this has implications that must be acknowledged:

> My position on this issue is not one of more or less aggregation [...] What I do say is that, at whatever level of aggregation our analysis may be carried on, [...] an evaluation of changes in productivity cannot leave without an explicit consideration the technical change which may occur in the production process of capital".
>
> (Pasinetti 1959, pp. 285-6)

Solow also rejects Pasinetti's statement that technical change in the capital goods industry is always capital-saving for the consumption goods industry. In fact, his idea on this issue is the traditional neoclassical one, i.e. technical progress in the production of productive capacity does not save labour:

> [w]hat it saves is an abstract "waiting". It now takes less saving to add a robot to the stock of capital than it did before.
>
> (Pasinetti 1959, p. 284, Solow's Comment)

It is our contention that one of the main drawbacks of many — both marginalist and other — analyses of technical change is that they fail in recognising changes in productivity as a physical, technological, phenomenon. Interestingly enough, Solow's comment to the quotation above is that it "is a true statement and an interesting statement. But it mixes up, *as such statement must*, technological and non-technological facts" (Pasinetti 1959, p. 284). Solow is referring to the fact that changes in the composition of demand influence Pasinetti's aggregate measure of technical change, and also that changes in the rate of profit result in *non*-neutral changes.

What Solow points out is of course true: any aggregate measure is influenced by changes in the sectoral composition of the economic system — from here the necessity of moving to sectoral measures. Moreover, changes in the rate of profit of course cause changes in capital intensity. However, Pasinetti's idea of measuring and classifying technical progress is strongly based, as we will see below, on the evolution of physical quantities. This point is raised in a very effective way in Pasinetti's reply to Solow's Comment:

> [A]part from short-run fluctuations, by far the largest part of changes in productivity over time have been shown to be due to technical change and only to a minor extent to changes in income distribution. I have simply suggested, therefore, an approach that focuses the investigation on the first cause, as opposed to the neo-classical analysis which focuses it on the second.
>
> (Pasinetti 1959, p. 285)

As will be seen in more detail, Pasinetti's (1959) paper, and the following debate with Solow, already contains, though sometimes in a still naive and embryonic way, many ideas and insights that will be further developed and incorporated in his approach to the analysis of structural economic dynamics and technical progress (Pasinetti 1973, Pasinetti 1981, Pasinetti 1988).

The 1959 paper came back to the fore again forty years later, in 1998, when a note written by Richard Stone in 1960 was posthumously published in *Structural Change and Economic Dynamics.* Stone's note starts from Pasinetti's (1959) original measure of productivity, setting it up in input-output terms. The last paragraph of such a note is particularly relevant for our purposes:

> In this analysis consumption and assets used up are reduced to their labour content and in this way made comparable. Technical progress is said to be capital saving, neutral or labour saving according as $\beta_1/\beta_0 \gtreqless 1$. The point of this note is that such statements can be based on data which are actually being provided by input-output analysts without any reference to the form of production functions except at the specific points of time under comparison.
>
> (Stone 1998[1960], p. 231)

The publication of Stone's (1998[1960]) note caused a further exchange between Pasinetti and Solow, showing that the original sources of disagreement had not disappeared in the course of those 40 years. But there clearly emerges that Pasinetti's (1959) paper has been written in the very same period in which he was working on his PhD Thesis, the first elaboration of his vertically hyper-integrated framework. Far away from being two independent works, they are two faces of the same coin, reflecting the intellectual turmoil that would have led to the formulation of the idea of vertical hyper-integration itself. Richard Stone, in 1960, had perfectly foreseen the natural development of Pasinetti's (1959) analytical apparatus: setting it up into input-output terms.

It is also quite clear that writing this paper has been a very important step in the genesis of Pasinetti's approach to economic analysis:

> My 1959 paper [. . .] originated as a paper for a seminar at the *Harvard Economic Research Project*, directed by Wassily Leontief, who was one of my supervisors while I was at Harvard University.
>
> (Pasinetti 1998, p. 233)

Leontief's legacy, as well as Sraffa's, is absolutely evident when carefully analysing Pasinetti's work.

1.1 Pasinetti's original measure

Pasinetti's (1959) analysis — as hinted at above — departs from Solow's (1957) paper, precisely from an analysis of technical progress "along traditional lines". Solow is criticised for not having considered the reproducible character of capital, and therefore the fact that technical progress can take place in its production too.

Thus, Pasinetti provides an extension of the analysis also including the production of productive capacity. He abandons a 'real' measure of capital, defining it in terms of capacity, i.e. with reference to the final (consumption) commodity for whose production process it is employed. First of all, "[t]he unit of measurement with which capital is [usually] measured is itself not independent of the rate of profit" (Pasinetti 1959, p. 271). But more importantly, this redefinition allows to focus attention, when dealing with the problem of measuring productivity changes, on the evolution of three ratios: Q/L, C/N and C/Q, where C is the capacity necessary for reproducing Q, Q is the quantity of the consumption commodity which is actually produced, L is the (direct) labour employed in its production process and N is the quantity of labour which would be necessary in order to reproduce the whole existing productive capacity.

Pasinetti (1959, p. 273) proposes to evaluate the direction of technical change by analysing the (relative) movements through time of Q/L and C/N, i.e. by computing the ratio:

$$\beta = \frac{Q/L}{C/N} \tag{1.1}$$

If a unit of capacity is defined as the composite commodity required exactly to reproduce one unit of the consumption commodity *at the time observations are made*, then there will be as many units of capacity as there are units of the consumption good in the net output. Therefore $Q = C$, the last ratio, Q/C, is constant through time and equal to unity, and β becomes:

$$\beta = \left.\frac{Q/L}{C/N}\right|_{Q=C} = \frac{N}{L} \tag{1.2}$$

According as to whether $d\ln\beta \gtreqqless 0$, technical change is labour-saving, neutral or capital-saving, respectively. Pasinetti (1959) bases his notion of neutrality on Harrod's conception (Pasinetti 1959, p. 274). To see this, he derives an equation for the value at current (production) prices of output of consumption goods and an equation for the value at current prices of productive capacity:

$$p_qQ = (\tau + r)p_cC + wa_qQ \tag{1.3}$$

$$p_cC = wa_kC \tag{1.4}$$

where $a_q = L/Q$, $a_k = N/C$ and τ (assuming linear depreciation) stands for the reciprocal of the length of life of the capital good.[2]

According to Harrod, in fact, the direction of technical progress can be classified on the basis of the movements of the capital/net output ratio for a constant profit rate:

$$\kappa = \frac{p_cC}{p_qQ} = \frac{a_kC}{(\tau + r)a_kC + a_qQ} = \frac{N}{(\tau + r)N + L} \tag{1.5}$$

Notice that when r is constant through time:

$$d\ln\kappa = \frac{\kappa}{\beta}d\ln\beta \tag{1.6}$$

i.e., the direction of changes in the capital/net output ratio κ always corresponds to the direction of movement of the index of technical change β.

1.2 Shortcomings of the original measure

The original index β proposed and measured by Pasinetti suffers from some shortcomings due to both the simplifying assumptions he adopted and the kind of data used for its computation.

First of all, it must be stressed that Pasinetti chose *not* to use Input-Output data, but rather aggregate figures from National Accounts. This is quite understandable given the aim of the paper, which was basically intended to be a critique of Solow's (neoclassical) approach to the study of technical progress, and not an empirical analysis of the phenomenon. Since the aim was theoretical, rather than specifically empirical, it was much more convenient

[2]These equations can be derived either within a traditional neoclassical framework, using an aggregate production function whose factors are paid their marginal products, or, "perhaps much better, in other theoretical frameworks, such as the Leontief models or the dynamic growth models which pay more attention to fixed coefficients and to idle capacity" (Pasinetti 1959, p. 275).

to use as manageable data as possible and to accordingly choose consistent simplifying assumptions.

Pasinetti assumes that all industries in the economic system produce either a capital or a consumption commodity. Moreover, he also implicitly assumes that capital goods are produced by means of labour alone — in fact, these are the very same assumptions that Pasinetti adopted in his doctoral thesis and in his 1981 book. The analogy becomes clearer when we compare equations (1.3) and (1.4) with the price equations of a growing subsystem with the technology of Pasinetti (1981): they share exactly the same characteristics.[3]

Clearly, while these assumptions can be accepted within a work aiming at reaching theoretical conclusions, when adopted in an empirical analysis they lead to results which are crude approximations of the magnitudes that are to be computed.

Moreover, and closely connected to the kind of data used for computations, the analysis carried out in Pasinetti's (1959) paper is an aggregate one. No sectoral measures are proposed or computed. This choice is not of course due to Pasinetti's denial of the importance of multisectoral analyses, but to the fact that performing an analysis of that kind was beyond the aim and scope of the paper — as stressed by Pasinetti himself in the quotation provided at page 5: "My position on this issue is not one of more or less aggregation" (Pasinetti 1959, p. 285). Nonetheless, it is clear — especially when one considers Pasinetti's more recent scientific production — that going from an aggregate to a multi-sectoral analysis is the natural development of the approach suggested in the paper we are discussing. And it is also clear — especially when one reads Stone's (1998[1960]) paper — that translating Pasinetti's (1959) framework into input-output terms is the way of improving it and giving it new life.

Finally, Pasinetti's original index of technical change mainly depends on nominal, rather than physical, magnitudes — quite obviously, given the restrictions imposed by the kind of data used for the estimation of β. The amount of labour that would be necessary for the reproduction of the existing capital stock (N) is estimated as the ratio of the capital stock at current

[3] In fact, by combining the equation sets (II.5.4) and (II.6.3) in Pasinetti (1981, pp. 39-41), the price equations for a growing subsystem i are:

$$p_i X_i = (1/T_i + \pi_i) p_{k_i} X_{k_i} + w a_{ni} X_i \tag{1.7}$$

$$p_{k_i} X_{k_i} = w a_{nk_i} X_{k_i} \tag{1.8}$$

with $\tau_i = 1/T_i$ (the reciprocal of the length of life of the subsystem-specific capital good i). The parallel with equations 1.3 and 1.4 becomes apparent.

prices to the average wage in the capital-producing sector. The latter is obtained as the ratio of the wage bill in the capital-producing industries to the corresponding labour force.

By calling K the value at current prices of the existing stock of capital; W and W_M the total wage bill and the wage bill in the capital goods sector, respectively; with w and w_M the corresponding average wage rates; and M the employment in the capital goods sector, one can write:

$$w_M = \frac{W_M}{M}, \qquad N = \frac{K}{w_M} = K\frac{M}{W_M}$$

and therefore

$$\beta = \frac{N}{L} = \frac{K}{L}\frac{M}{W_M} = \frac{K}{W}\left(\frac{M}{L}\frac{W}{W_M}\right)$$

Therefore, when computed in this way, β is given by the product of two components: the capital/wages ratio and a scale factor. Looking at this scale factor more in detail, we see that in its turn is the product of two components: the ratio of employment in investment goods industry to employment in the consumption goods industry, and the ratio of overall wage bill to the wage bill of the capital goods industry. In this way, not only β strongly depends on nominal magnitudes, but it is also going to show a co-movement with the capital/wages ratio.

In fact, by reproducing Pasinetti's (1959) original empirical exercise for the Italian economy between 1980 and 2007, this co-movement clearly appears, as displayed by figure 1.

The solid line representing the fixed-capital-net-output ratio (K/Q) experiences only mild changes (less than ± 5 p.p. from 1985 onwards), while the fixed-capital-wages ratio (the dashed line K/W) increases until mid 1980s, remains nearly constant until the beginning of 1990s, and sharply increases afterwards. As to β (the two-dashed line), though being close to K/Q during the first ten years, this is no longer so afterwards and, in fact, β clearly co-moves with K/W during the whole period.

1.3 Towards a reformulation

The above mentioned shortcomings are basically connected with Pasinetti's (1959) empirical implementation of his theoretical ideas. The necessity of using manageable data in order to get ready estimates also compelled the choice of the simplifying assumptions and forced the computation of rough approximations of the theoretical magnitudes.

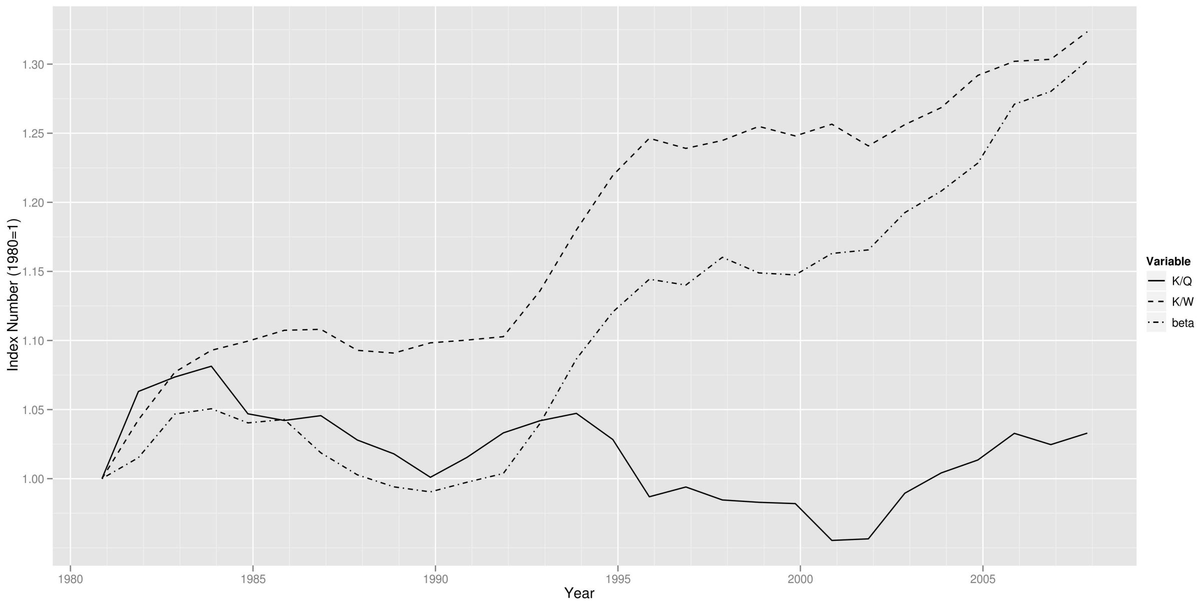

Figure 1: Dynamics of Fixed Capital to Wages (K/W), Fixed Capital to Net-Output (K/Q) and β (beta) for Italy 1980-2007

It is our contention, however, that the ideas at the basis of Pasinetti's (1959) theoretical proposal are correct and worth being developed with the aid of the theoretical developments that followed on the one hand, and input-output data and techniques, on the other.

In particular, we want to stress four theoretical features of Pasinetti's (1959) proposal which deserve particular attention — and which have then been further developed by Pasinetti himself.

First of all, an analysis of technical change cannot deny the fact that progress does not only take place in the production of consumption commodities, but also affects the process of (re)production of capital goods. Stressing the importance of this phenomenon — in sharp contrast with the neoclassical approach followed by Solow (1957) — was the principal aim of Pasinetti's (1959) paper.

Secondly, and closely connected to the previous point, Pasinetti (1959) uses a definition of net output different from the traditional one, including only consumption commodities.[4] New investments, together with replace-

[4]In fact, note that when he computes the 'capital-output' ratio in Pasinetti (1959, p. 277, Table 2) the values 3.125595 (for 1929) and 2.6574374 (for 1950) are computed with Q (net output) taken to be real consumption goods production, and *not* consumption *plus* gross investment demand.

ments, are part of the means of production and not of the net product. This idea has been very important in the elaboration of the concept of *growing* subsystems, and allowed Pasinetti to go into dynamic analysis and studying the problem of capital accumulation.

Another feature which has been introduced in the 1959 article, though present throughout Pasinetti's works, is that of measuring the stock of capital in terms of units of productive capacity, rather than in ordinary physical units. In this way, it is possible to study the problem of capital accumulation separately from that of the composition of the stock of capital itself, and in close connection with the evolution of final demand for consumption commodities.

Finally, and most importantly, productivity accounting must be based on the evolution of *physical*, and not nominal, magnitudes. In fact, the concept of productivity is a purely physical-technical one, and the *measurement* of its evolution through time has nothing to do with changes in income distribution and market prices.

In order to develop this ideas and implement them empirically, we are going to reformulate the analytical apparatus incorporating more recent theoretical developments and taking into account the intrinsically multisectoral nature of productivity measures.

First, we are going to change the kind of data used for computing productivity measures. In particular, we will use input-output data. More specifically, in order to incorporate pure joint production from the very beginning, we will use the set of Supply-Use Tables (SUT) instead of single-product Input-Output Tables.

Second, we will change the unit of analysis: our sectoral measures will not be computed at the single-industry level, but will refer to growing subsystems, i.e. to vertically hyper-integrated sectors (see Pasinetti 1988). This step is the analytical counterpart of incorporating the above mentioned redefinition of the concept of net output: as will be seen in section 2.1, in fact, this very redefinition is at the basis of the hyper-integrated repartition of economic activities leading to the — analytical — construction of growing subsystems.

2 A reformulation of Pasinetti's original measure

Before going into the details of the present reformulation, it is worth spending a few lines for introducing the basic notation. The choice was that of keeping as close as possible to the standard notation used in Input-Output literature when referring to magnitudes coming from the System of National

Accounts. While presenting, in section 2.1, the method of (growing) subsystems, the correspondences with respect to the original notation used by Pasinetti (1973) and Pasinetti (1988) — i.e. the two articles in which he developed the concepts of vertical integration and hyper-integration, respectively — will be detailed.

In order not to make notation too heavy, we are going to distinguish a physical-quantity matrix from the corresponding one in nominal terms simply by adding the subscript $_q$; moreover, in general, almost all magnitudes will refer to time period t; in case of exceptions, the time lag i with respect to time period t will be indicated with the subscript $_{\pm i}$. So, for example, while matrix $\mathbf{U}$ will denote the stock of circulating capital, evaluated at current prices, in time period t, matrix $\mathbf{U}_{q(-1)}$ will denote the stock of circulating capital, in physical terms, referring to time period $t-1$. In the same way, all magnitudes without different specification will be intended as domestically produced ones; in all cases in which it will be necessary to refer to the imported part or to the total, i.e. the sum of domestically produced and imported part, of any magnitude, we will do it by means of the superscripts ^{m} and *, respectively.

The accounting framework representing our point of departure can therefore be set up in terms of the following magnitudes — all matrices being (commodity $\times$ activity) square ones:

- $\mathbf{U}$: matrix of circulating capital inputs;
- $\mathbf{V}$: matrix of gross outputs;
- $\mathbf{F}_k$: matrix of gross fixed capital formation;
- $\mathbf{f}_c$: final consumption in nominal terms. It is the sum of three components: private consumption ($\mathbf{f}_{c_p}$), public expenditure ($\mathbf{f}_g$), and exports ($\mathbf{f}_x$);
- $\mathbf{c}$: final consumption in physical terms;
- $\mathbf{e}$: vector of activity intensities, in our case a sum vector, i.e. a vector of ones;
- $\mathbf{e}_i$: vector with a 1 in the i-th position, all other elements being zeros;
- $\mathbf{l}$: vector of total employment;
- $\mathbf{K}$: matrix of gross stocks of fixed capital;
- $\mathbf{J}_k$: matrix new investment in fixed capital;
- $\mathbf{J}$: matrix of new investment in circulating capital;
- $\mathbf{p}_s$: vector of statistical basic prices;
- $\mathbf{R}$: matrix of retirements of fixed capital inputs.

2.1 The method of (growing) subsystems

In this section, we compute vertically integrated and vertically hyper-integrated sectors, respectively, starting from a set of Supply-Use Tables.

In order to do so, we start from the *material product balances*. Gross outputs are identically equal to:

$$\mathbf{V}_q\mathbf{e} \equiv \mathbf{U}_q\mathbf{e} + \mathbf{F}_{k_q}\mathbf{e} + \mathbf{c} \tag{2.1}$$

while the stock of fixed capital, both domestically produced and imported, is identically equal to:

$$\begin{aligned} \mathbf{K}_q &\equiv \mathbf{K}_{q(-1)} + \mathbf{F}_{k_q} - \mathbf{R}_q \\ \mathbf{K}^m_q &\equiv \mathbf{K}^m_{q(-1)} + \mathbf{F}^m_{k_q} - \mathbf{R}^m_q \end{aligned} \tag{2.2}$$

i.e. to the stock inherited from the previous period plus gross investments undertaken in the present period minus retirements. To put it in another way, the increase in the stock of fixed capital is given by gross investments net of retirements:

$$\begin{aligned} \mathbf{K}_q - \mathbf{K}_{q(-1)} &\equiv \mathbf{F}_{k_q} - \mathbf{R}_q \\ \mathbf{K}^m_q - \mathbf{K}^m_{q(-1)} &\equiv \mathbf{F}^m_{k_q} - \mathbf{R}^m_q \end{aligned} \tag{2.3}$$

Vertically integrated sectors

Establishing a correspondence between the theoretical magnitudes appearing in Pasinetti's (1973) article on vertical integration is not a straightforward task due to complications implied by the presence of imported commodities (including capital goods), and by the treatment of fixed capital, which also involves the distinction between retirements and replacements and the separation between the latter and new investments.

It is however possible to set up an initial correspondence by neglecting for a moment the role of imported commodities[5] and assuming, as Pasinetti (1973) does, that replacements are constant through time.

In this way, the material product balance (2.1) can be written as:

$$\begin{aligned} \mathbf{V}_q\mathbf{e} &= \mathbf{U}_q\mathbf{e} - \mathbf{U}_{q(-1)}\mathbf{e} + \mathbf{U}_{q(-1)}\mathbf{e} + \mathbf{R}_q\mathbf{e} + \mathbf{J}_{k_q}\mathbf{e} + \mathbf{c} = \\ &= \mathbf{J}_q\mathbf{e} + \mathbf{U}_{q(-1)}\mathbf{e} + \mathbf{R}_q\mathbf{e} + \mathbf{J}_{k_q}\mathbf{e} + \mathbf{c} \end{aligned} \tag{2.4}$$

[5] Removing this assumption will entail difficulties only as regards fixed capital, since the treatment of circulating capital is not complicated by the presence of imports. In fact, the stock of circulating capital at the beginning of each productive period is simply given by the quantity of circulating capital bought by each industry in the previous one. National Accounts always separate domestic purchases from imports, and domestic commodity balances have to take into account circulating capital goods which have actually been *produced* for intermediate uses.

from which we get:

$$(\mathbf{V}_q - \mathbf{U}_{q(-1)} - \mathbf{R}_q)\mathbf{e} = \mathbf{J}_q\mathbf{e} + \mathbf{J}_{k_q}\mathbf{e} + \mathbf{c} \tag{2.5}$$

We can now compare expression (2.5) with the original system appearing in Pasinetti (1973).[6]

The first apparent difference is a consequence of introducing pure joint production. Specifically, the original vector of gross quantities, $\mathbf{X}(t)$, is here replaced by the unitary vector of activity intensities $\mathbf{e}$. Accordingly, the original identity matrix — in $(\mathbf{I} - \mathbf{A}^{\ominus})$ — is here replaced by the matrix of gross outputs.

Matrix $\mathbf{A}^{\ominus} := (\mathbf{A}^{(C)} + \mathbf{A}^{(F)}\widehat{\boldsymbol{\delta}})$, "representing that part of the initial stocks of capital goods that are actually used up each year by the production process" (Pasinetti 1973, p. 4) is given, in our formulation, by $(\mathbf{U}_{q(-1)} + \mathbf{R}_q)$.

Here we come to an important point. Matrix $\mathbf{U}_q$ is not the same as matrix $\mathbf{A}^{(C)}$ of input requirements of circulating capital per unit of gross output. In fact, the Use Table collected by statistical institutes "includes all non-durable goods and services with an expected life of less than one year which are used up in the process of production by industries" (EUROSTAT 2008, p. 146), and is obtained by measuring the transactions effectively carried out *during* the accounting period net of changes in inventories of circulating capital. Thus, it cannot be taken to represent the nominal counterpart of a matrix of technical coefficients, as growth is implicitly contained in it. It is not possible to separate the unitary input requirements from the level of operation of each industry in observed empirical structures.

Therefore, such transactions include both the circulating capital that goes to replace the commodities actually used up, *and* those intermediate inputs that are purchased in order to expand production in the following period. This means that:

$$\mathbf{U}_q = \mathbf{A}^{(C)}\widehat{\mathbf{X}}(t) + \mathbf{J}_q$$

[6] The original expression is (see Pasinetti 1973, expression (2.1), p. 4):

$$\left(\mathbf{I} - \mathbf{A}^{\ominus}\right)\mathbf{X}(t) = \mathbf{Y}(t)$$

where:

$$\mathbf{A} := \mathbf{A}^{(C)} + \mathbf{A}^{(F)}$$
$$\mathbf{A}^{\ominus} := \mathbf{A}^{(C)} + \mathbf{A}^{(F)}\widehat{\boldsymbol{\delta}}$$

and therefore:

$$\mathbf{U}_{q(-1)} = \mathbf{A}^{(C)}_{(-1)}\widehat{\mathbf{X}}(t-1) + \mathbf{J}_{q(-1)} = \mathbf{A}^{(C)}\widehat{\mathbf{X}}(t)$$

Before removing the above mentioned simplifications and going back to the general case, it is worth devoting a few lines to the explanation of our choice not to consider depreciation as a measure of replacements.

Depreciation is a book-keeping concept, belonging to the value-added side of the economy. As such, it does not have a physical counterpart. According to book-keeping (linear) depreciation schemes, when a new machine is bought and enters productive capacity, in order not to alter the cost/profits relation in the corresponding accounting period, an estimate of its life-time is made. The value of the machine is then split into as many parts as its estimated life-time, and thus spread over the whole period, in order to smooth the associated increase of the costs of production. This has nothing to do with the purely physical concept of replacements, which instead pertain exclusively to the expenditure side of the system, having as physical counterpart the material product balance equations.[7]

Expressions (2.2) and (2.3), are important in order to understand the conceptual distinction between *retirements* and replacements.

Current retirements, contrary to replacements, do not affect the magnitude of gross investments; they emerge at the end of the production period, *after* investments have been undertaken, but *before* determining the composition of the stock of fixed capital available at the end of the period.

In other words, at the beginning of the production period, the available stock of fixed capital is given by $\mathbf{K}_{q(-1)}$, i.e. by the stock of capital measured at the end of the previous period after accounting for retirements. Then, gross investments are undertaken, and go to increase the initial stock. At the end of the time period, before measuring the final stock, obsolete machines are retired and thus retirements accounted for in the determination of the final stock of fixed capital.

Replacements, on the contrary, do determine the amount of gross investment, being one of its components. From an empirical point of view, we might say that replacements are given by retirements measured at the end of period $t-1$, i.e. $\mathbf{R}_{q(-1)}$.[8] In this way, current total (domestically produced

[7]In his 1959 paper, Pasinetti had already noticed that "[a]ll quantities could be interpreted in *net* terms but, since depreciation allowances always contain elements of arbitrariness, it is better to work with gross quantities" (Pasinetti 1959, p. 275). This issue becomes even more crucial in the discussion of vertical hyper-integration, as will be made clear below.

[8]It could be objected that this amounts to assuming continuous full utilisation of pro-

plus imported) gross investments can be written as:

$$\mathbf{F}^*_{k_q} = \mathbf{R}^*_{q(-1)} + \mathbf{J}^*_{k_q} \tag{2.6}$$

However, the problem is that, while in the case of retirements — i.e. of expressions (2.2) and (2.3) — it is perfectly possible to separate domestically produced from imported components, in the case of replacements — i.e. of expression (2.6) for gross investments — there is a lagged variable, and therefore this separation is not possible anymore.

In fact, with reference to period $t-1$, we can separate the retirements of domestically produced machines ($\mathbf{R}_{q(-1)}$) from those of imported ones ($\mathbf{R}^m_{q(-1)}$), but we cannot consistently state that these retirements correspond to replacements of domestically produced and imported machines in the following, i.e. the current, period. It might well be that part of the retired machines previously domestically produced are now imported, and vice versa.

In passing from a period to the following one, therefore, the correspondence between retirements in $t-1$ and replacements in t can be established only for the total stock of fixed capital, without distinction.[9]

In analytical terms, when talking about retirements in period $t-1$ we would consistently write:

$$\mathbf{R}^*_{q(-1)} \equiv \mathbf{R}_{q(-1)} + \mathbf{R}^m_{q(-1)}$$

while, when talking of replacements in period t, we would ideally write:

$$\mathbf{R}^*_{q(-1)} \equiv \mathbf{\Theta} \otimes \mathbf{R}^*_{q(-1)} + (\mathbf{I} - \mathbf{\Theta}) \otimes \mathbf{R}^*_{q(-1)}$$

where $\otimes$ indicates element-wise matrix multiplication.

The elements of $\mathbf{\Theta}$ and of $\mathbf{I} - \mathbf{\Theta}$ are the proportions of all the machines retired in $t-1$ that will be replaced in t by domestically produced and by

ductive capacity. However, to conceive a self-replacement situation as one in which obsolete machines become replaced by new ones automatically translates into negative new investment, if not enough capacity is being created.

[9] We are implicitly assuming that all gestation periods correspond to one production period. This is not a realistic assumption. Removing it would imply a series of complications regarding the analytical formulation and the data requirements for estimates. Moreover, the column of gross fixed capital formation of the Use Table — as empirically implemented — contains *only* acquisition less disposal of fixed assets, while work-in-progress (which constitute production during the current accounting period in need of further processing to be sellable) are instead included in the vector of changes in inventories (for details, see EUROSTAT 2008, pp. 154-6). Hence, applying uniform gestation period data by commodity on gross fixed capital formation would not be an accurate procedure.

imported machines, respectively. However, matrix $\mathbf{\Theta}$ is seldom ever available in empirical terms, so that actually we cannot separate domestic from imported replacements.

This represents a problem when operating at the vertically integrated level, since the construction of self-replacing subsystems requires to be able to isolate the net product, which is given by the final demand for consumption commodities and *domestically produced* new investments.

In order to overcome this difficulty, we make an assumption that, though being in some respects arbitrary, is in our opinion better than assuming that retirements — and thus replacements — are constant through time, both as regards the domestically produced as well as the imported stock of fixed capital. More precisely, we will assume that, for each *commodity*, the proportion of imported (domestic) replacements to total retirements of the previous period is the same as the proportion of imported (domestic) to total fixed capital gross investment. Thus, we estimate a *diagonal* replacement-proportions matrix $\widehat{\boldsymbol{\theta}}$ as follows:

$$\widehat{\boldsymbol{\theta}} = \widehat{\mathbf{f}}_{k_q} \left(\widehat{\mathbf{f}}^*_{k_q}\right)^{-1} \qquad (\mathbf{I} - \widehat{\boldsymbol{\theta}}) = \widehat{\mathbf{f}}^m_{k_q} \left(\widehat{\mathbf{f}}^*_{k_q}\right)^{-1}$$

where:

$$\mathbf{f}_{k_q} = \mathbf{F}_{k_q}\mathbf{e}; \qquad \mathbf{f}^m_{k_q} = \mathbf{F}^m_{k_q}\mathbf{e}; \qquad \mathbf{f}^*_{k_q} = \mathbf{F}^*_{k_q}\mathbf{e}$$

and, therefore, domestically produced and imported gross investment matrices are given by:

$$\begin{aligned} \mathbf{F}_{k_q} &= \widehat{\boldsymbol{\theta}}\mathbf{R}^*_{q(-1)} + \mathbf{J}_{k_q} \\ \mathbf{F}^m_{k_q} &= (\mathbf{I} - \widehat{\boldsymbol{\theta}})\mathbf{R}^*_{q(-1)} + \mathbf{J}^m_{k_q} \end{aligned} \tag{2.7}$$

We can now go back to expression (2.4) and, using expression (2.7), write it as:

$$\mathbf{V}_q\mathbf{e} = \mathbf{U}_{q(-1)}\mathbf{e} + \mathbf{J}_q\mathbf{e} + \mathbf{J}_{k_q}\mathbf{e} + \widehat{\boldsymbol{\theta}}\mathbf{R}^*_{q(-1)}\mathbf{e} + \mathbf{c}$$

which, rearranging, leads to:

$$\mathbf{e} = \left(\mathbf{V}_q - \mathbf{U}_{q(-1)} - \widehat{\boldsymbol{\theta}}\mathbf{R}^*_{q(-1)}\right)^{-1} \left(\mathbf{J}_q\mathbf{e} + \mathbf{J}_{k_q}\mathbf{e} + \mathbf{c}\right) \tag{2.8}$$

It is now possible to define, by taking advantage of expression (2.8), the concepts of vertically integrated productive capacity and labour, respectively:

$$\begin{aligned} \mathbf{S}^*_{k_q}\mathbf{e} &= \left(\mathbf{K}^*_{q(-1)} + \mathbf{U}^*_{q(-1)}\right)\mathbf{e} = \\ &= \left(\mathbf{K}^*_{q(-1)} + \mathbf{U}^*_{q(-1)}\right)\left(\mathbf{V}_q - \mathbf{U}_{q(-1)} - \widehat{\boldsymbol{\theta}}\mathbf{R}^*_{q(-1)}\right)^{-1}\left(\mathbf{J}_q\mathbf{e} + \mathbf{J}_{k_q}\mathbf{e} + \mathbf{c}\right) = \\ &= \mathbf{H}\left(\mathbf{J}_q\mathbf{e} + \mathbf{J}_{k_q}\mathbf{e} + \mathbf{c}\right) \end{aligned}$$

and

$$\begin{aligned} L &= \mathbf{l}^T \mathbf{e} = \\ &= \mathbf{l}^T \left(\mathbf{V}_q - \mathbf{U}_{q(-1)} - \widehat{\boldsymbol{\theta}} \mathbf{R}^*_{q(-1)} \right)^{-1} \left(\mathbf{J}_q \mathbf{e} + \mathbf{J}_{k_q} \mathbf{e} + \mathbf{c} \right) = \\ &= \boldsymbol{\nu}^T \left(\mathbf{J}_q \mathbf{e} + \mathbf{J}_{k_q} \mathbf{e} + \mathbf{c} \right) \end{aligned}$$

where:

$$\mathbf{H} := \left(\mathbf{K}^*_{q(-1)} + \mathbf{U}^*_{q(-1)} \right) \left(\mathbf{V}_q - \mathbf{U}_{q(-1)} - \widehat{\boldsymbol{\theta}} \mathbf{R}^*_{q(-1)} \right)^{-1} \tag{2.9}$$

is the matrix of vertically integrated productive capacity, and:

$$\boldsymbol{\nu}^T := \mathbf{l}^T \left(\mathbf{V}_q - \mathbf{U}_{q(-1)} - \widehat{\boldsymbol{\theta}} \mathbf{R}^*_{q(-1)} \right)^{-1} \tag{2.10}$$

is the vector of vertically integrated labour coefficients.

Let us also define the total quantity of labour employed in each vertically integrated sector i as:

$$L_\nu^{(i)} = \boldsymbol{\nu}^T \widehat{\mathbf{y}} \mathbf{e}_i = \nu_i y_i \tag{2.11}$$

where $\mathbf{y} = \mathbf{J}_q \mathbf{e} + \mathbf{J}_{k_q} \mathbf{e} + \mathbf{c}$ is the net product vector.

Note that the units of productive capacity (the columns of $\mathbf{H} = [\mathbf{h}_i]$) consist of both domestically produced and imported stock matrices of circulating and fixed capital inputs. This will also hold in the vertically hyper-integrated case.

Clearly, National Accounts do not include physical, but only nominal magnitudes. This means that our actual commodity balance is

$$\mathbf{V}\mathbf{e} = \mathbf{U}_{(-1)}\mathbf{e} + \mathbf{J}\mathbf{e} + \mathbf{J}_k \mathbf{e} + \widehat{\boldsymbol{\theta}} \mathbf{R}^*_{(-1)} \mathbf{e} + \mathbf{f}_c$$

i.e.

$$\widehat{\mathbf{p}}_s \mathbf{V}_q \mathbf{e} = \widehat{\mathbf{p}}_s \left(\mathbf{U}_{q(-1)} \mathbf{e} + \mathbf{J}_q \mathbf{e} + \mathbf{J}_{k_q} \mathbf{e} + \widehat{\boldsymbol{\theta}} \mathbf{R}^*_{q(-1)} \mathbf{e} + \mathbf{c} \right)$$

Therefore, the absolute magnitudes we can actually compute depend on statistical prices:

$$\begin{aligned} \widehat{\mathbf{p}}_s \mathbf{H} \widehat{\mathbf{p}}_s^{-1} &= \widehat{\mathbf{p}}_s \left(\mathbf{K}^*_{q(-1)} + \mathbf{U}^*_{q(-1)} \right) \left(\mathbf{V}_q - \mathbf{U}_{q(-1)} - \widehat{\boldsymbol{\theta}} \mathbf{R}^*_{q(-1)} \right)^{-1} \widehat{\mathbf{p}}_s^{-1} \\ \boldsymbol{\nu}^T \widehat{\mathbf{p}}_s^{-1} &= \mathbf{l}^T \left(\mathbf{V}_q - \mathbf{U}_{q(-1)} - \widehat{\boldsymbol{\theta}} \mathbf{R}^*_{q(-1)} \right)^{-1} \widehat{\mathbf{p}}_s^{-1} \end{aligned}$$

But this is not so for variations through time of the vector of vertically integrated labour coefficients and of the *units of* vertically integrated productive capacity — i.e. of the *columns* of matrix $\mathbf{H}$. In fact, since data allow us to express all periods' magnitudes at constant prices, when computing variations through time the effect of prices vanishes:

$$\left(\boldsymbol{\nu}^T\widehat{\mathbf{p}}_s^{-1} - \boldsymbol{\nu}_{(-1)}^T\widehat{\mathbf{p}}_s^{-1}\right)\widehat{\mathbf{p}}_s(\widehat{\boldsymbol{\nu}}_{(-1)})^{-1} = \left(\boldsymbol{\nu}^T - \boldsymbol{\nu}_{(-1)}^T\right)(\widehat{\boldsymbol{\nu}}_{(-1)})^{-1}$$
$$p_j(\widehat{\mathbf{h}}_{j(-1)})^{-1}\widehat{\mathbf{p}}_s^{-1}\left(\widehat{\mathbf{p}}_s\mathbf{h}_j p_j^{-1} - \widehat{\mathbf{p}}_s\mathbf{h}_{j(-1)}p_j^{-1}\right) = (\widehat{\mathbf{h}}_{j(-1)})^{-1}\left(\mathbf{h}_j - \mathbf{h}_{j(-1)}\right)$$

Vertically hyper-integrated sectors

Recovering data for building vertically hyper-integrated sectors is much easier, in empirical terms, than for vertically integrated ones. In fact, building growing sub-systems requires first of all a redefinition of the concept of net output, involving demand for final consumption commodity only; *all* investments, and not only replacements, are part of the means of production, and therefore there is no need to estimate the current replacements matrix in order to separate the two components of gross investment as we did in expression (2.7).

In order to arrive to the vertically hyper-integrated formulation, we can start straightforwardly from expression (2.1), i.e. from our initial material product balance:

$$\mathbf{V}_q\mathbf{e} \equiv \mathbf{U}_q\mathbf{e} + \mathbf{F}_{k_q}\mathbf{e} + \mathbf{c} \tag{2.1}$$

To find a correspondence between our formulation and Pasinetti's (1988) original one, it is necessary to take into account that Pasinetti treated fixed capital as a joint product, in the tradition of Sraffa (1960).[10] Instead, we adopt an empirically more tractable procedure, working with gross fixed capital formation and fixed capital stock matrices, though incorporating pure joint production.

As we stressed at the beginning of the section devoted to vertical integration, matrix $\mathbf{U}_q$ — and also $\mathbf{F}_{k_q}$ — already include *growth*; i.e. they involve both replacements and new investments. Therefore, our statistical outlay — based, it is worth stressing the point again, on *transactions* that actually took place during the whole accounting period — is much more suitable for vertically hyper-integrated analyses than for vertically integrated ones. The separation between replacements and new investments, which always has to be estimated and therefore is always somewhat artificial, is not at all necessary here. In fact:

[10]The original expression is (see Pasinetti 1989, expression (2.1a), p. 479):

$$\mathbf{AX}(t) + g\mathbf{AX}(t) + \mathbf{C}(t) + \mathbf{A}\sum r_i\mathbf{X}^{(i)}(t) = \mathbf{BX}(t)$$

> [w]ith technical change going on, each machine is never replaced by an exact similar physical machine, and this makes it impossible to say what is that is replaced and kept intact. Measurement in terms of units of [hyper-integrated] productive capacity overcomes this possibility.
>
> (Pasinetti 1981, p. 178)

Therefore, the vector of operation intensities $\mathbf{X}(t)$ is here replaced by the unitary vector $\mathbf{e}$ and $\mathbf{B}$ corresponds to $\mathbf{V}_q$. The most apparent difference is represented by the fact that it is not possible to find a one-to-one correspondence between Pasinetti's (1989) matrices $\mathbf{A}$, $g\mathbf{A}$, $\mathbf{A}\sum r_i\mathbf{X}^{(i)}(t)$ and our matrices $\mathbf{U}_q$ and $\mathbf{F}_{k_q}$, but rather:

$$\mathbf{U}_q\mathbf{e} + \mathbf{F}_{k_q}\mathbf{e} = \mathbf{A}\mathbf{X}(t) + g\mathbf{A}\mathbf{X}(t) + \mathbf{A}\sum r_i\mathbf{X}^{(i)}(t)$$

Once this correspondence has been established, we can directly write:

$$\mathbf{e} = \left(\mathbf{V}_q - \mathbf{U}_q - \mathbf{F}_{k_q}\right)^{-1}\mathbf{c}$$

$$\mathbf{S}^*_{k_q}\mathbf{e} = \left(\mathbf{K}^*_{q(-1)} + \mathbf{U}^*_{q(-1)}\right)\left(\mathbf{V}_q - \mathbf{U}_q - \mathbf{F}_{k_q}\right)^{-1}\mathbf{c} = \mathbf{M}\mathbf{c} \tag{2.12}$$

$$L = \mathbf{l}^T\left(\mathbf{V}_q - \mathbf{U}_q - \mathbf{F}_{k_q}\right)^{-1}\mathbf{c} = \boldsymbol{\eta}^T\mathbf{c} \tag{2.13}$$

where:

$$\mathbf{M} := \left(\mathbf{K}^*_{q(-1)} + \mathbf{U}^*_{q(-1)}\right)\left(\mathbf{V}_q - \mathbf{U}_q - \mathbf{F}_{k_q}\right)^{-1} \tag{2.14}$$

is the matrix of vertically hyper-integrated productive capacities, and

$$\boldsymbol{\eta}^T := \mathbf{l}^T\left(\mathbf{V}_q - \mathbf{U}_q - \mathbf{F}_{k_q}\right)^{-1} \tag{2.15}$$

is the vector of vertically hyper-integrated labour coefficients.

Let us also define the total quantity of labour employed in each vertically hyper-integrated sector i as:

$$L^{(i)}_\eta = \boldsymbol{\eta}^T\widehat{\mathbf{c}}\mathbf{e}_i = \eta_i c_i \tag{2.16}$$

Moreover, note that:

$$\sum_{i=1}^{n} L^{(i)}_\eta = \sum_{i=1}^{n}\boldsymbol{\eta}^T\widehat{\mathbf{c}}\mathbf{e}_i = \boldsymbol{\eta}^T\widehat{\mathbf{c}}\sum_{i=1}^{n}\mathbf{e}_i = \boldsymbol{\eta}^T\widehat{\mathbf{c}}\mathbf{e} = \boldsymbol{\eta}^T\mathbf{c} = L \tag{2.17}$$

i.e. growing subsystems exhaust total employment of the economy.[11]

[11] It is straightforward to see that this also holds for self-replacing subsystems, i.e. vertically integrated sectors.

Also in this case, since we are starting from a *nominal* product balance, we cannot compute $\mathbf{M}$ and $\boldsymbol{\eta}^T$, but rather:

$$\begin{aligned}\widehat{\mathbf{p}}_s \mathbf{M} \widehat{\mathbf{p}}_s^{-1} &= \widehat{\mathbf{p}}_s \left(\mathbf{K}^*_{q(-1)} + \mathbf{U}^*_{q(-1)}\right) \left(\mathbf{V}_q - \mathbf{U}_q - \mathbf{F}_{k_q}\right)^{-1} \widehat{\mathbf{p}}_s^{-1} \\ \boldsymbol{\eta}^T \widehat{\mathbf{p}}_s^{-1} &= \mathbf{l}^T \left(\mathbf{V}_q - \mathbf{U}_q - \mathbf{F}_{k_q}\right)^{-1} \widehat{\mathbf{p}}_s^{-1}\end{aligned}$$

However, as in the previous case, computing changes through time allows to get rid of the price effects:

$$\begin{aligned}\left(\boldsymbol{\eta}^T \widehat{\mathbf{p}}_s^{-1} - \boldsymbol{\eta}^T_{(-1)} \widehat{\mathbf{p}}_s^{-1}\right) \widehat{\mathbf{p}}_s (\widehat{\boldsymbol{\eta}}_{(-1)})^{-1} &= \left(\boldsymbol{\eta}^T - \boldsymbol{\eta}^T_{(-1)}\right) (\widehat{\boldsymbol{\eta}}_{(-1)})^{-1} \\ p_j (\widehat{\mathbf{m}}_{j(-1)})^{-1} \widehat{\mathbf{p}}_s^{-1} \left(\widehat{\mathbf{p}}_s \mathbf{m}_j p_j^{-1} - \widehat{\mathbf{p}}_s \mathbf{m}_{j(-1)} p_j^{-1}\right) &= (\widehat{\mathbf{m}}_{j(-1)})^{-1} \left(\mathbf{m}_j - \mathbf{m}_{j(-1)}\right)\end{aligned}$$

where $\mathbf{m}_j$ is the j-th column of matrix $\mathbf{M}$.

2.2 Measures of changes in productivity

On the basis of the methods described in section 2.1, we are therefore going to compute a series of vertically (hyper-)integrated measures of changes in labour productivity — both at the sectoral level and for the economic system as a whole — and a sectoral and an aggregate index of the direction of technical change.

In order to ease exposition, we will give the analytical formulation of the above mentioned measures of labour productivity in absolute terms. We have already shown, in the previous section, that computing variations make the influence of prices to disappear, so that it is not necessary to repeat the proof here.

The labour productivity of each *vertically integrated* sector i is given by the ratio of the net product — in this case given by consumption and new investments: $y_i = \mathbf{e}_i^T \mathbf{J}_q \mathbf{e} + \mathbf{e}_i^T \mathbf{J}_{k_q} \mathbf{e} + c_i$ — to total labour force employed in the vertically integrated sector itself:

$$\alpha_\nu^{(i)} = \frac{y_i}{L_\nu^{(i)}} = \frac{y_i}{\nu_i y_i} = \frac{1}{\nu_i} = \left(\mathbf{l}^T \left(\mathbf{V}_q - \mathbf{U}_{q(-1)} - \widehat{\boldsymbol{\theta}} \mathbf{R}^*_{q(-1)}\right)^{-1} \mathbf{e}_i\right)^{-1}$$

In the same way, labour productivity in each *vertically hyper-integrated* sector i is given by the ratio of the net product, which in this case consists of final consumption only, to the total labour force employed in the sector as a whole:

$$\alpha_\eta^{(i)} = \frac{c_i}{L_\eta^{(i)}} = \frac{c_i}{\eta_i c_i} = \frac{1}{\eta_i} = \left(\mathbf{l}^T \left(\mathbf{V}_q - \mathbf{U}_q - \mathbf{F}_{k_q}\right)^{-1} \mathbf{e}_i\right)^{-1}$$

Another sectoral measure of labour productivity, which we compute in vertically hyper-integrated terms only, is

$$N_{\eta}^{(i)} = \boldsymbol{\eta}^T \mathbf{m}_i c_i \tag{2.18}$$

i.e. the quantity of *co-existing* vertically hyper-integrated labour that would be necessary for the reproduction of the existing productive capacity with the technique actually in use.

The last measure of labour productivity is an aggregate one, i.e. Pasinetti's (1981) *standard rate of growth of productivity*, though computed in vertically hyper integrated terms and within a complete inter-industry relations framework:

$$\rho^* = \frac{\sum_{i=1}^{n} L_{\eta}^{(i)} \operatorname{dln} \alpha_{\eta}^{(i)}}{\sum_{i=1}^{n} L_{\eta}^{(i)}} = \sum_{i=1}^{n} \frac{L_{\eta}^{(i)}}{L} \operatorname{dln} \alpha_{\eta}^{(i)} \tag{2.19}$$

The standard rate of growth of productivity is therefore given by the weighted average of the rate of growth of labour productivity in the different vertically hyper-integrated sectors, the weights being the ratio of total labour employed in the corresponding growing subsystem to total labour in the economic system as a whole.

Finally, we are going to compute an aggregate index and a set of sectoral indexes of the direction of technical change, both being re-elaborations of Pasinetti's (1959) original index β. As we are going to see in a moment, in this case it is possible to compute absolute levels rather than variations through time. In fact, all these indexes are ratios of vertically hyper-integrated labour necessary for the production of the net output, i.e. of final consumption, to vertically hyper-integrated co-existing labour for the reproduction of the existing productive capacity, either aggregate or sectoral, as given by expression (2.18).

In particular, the economy-wide index is given by:

$$\beta^* = \frac{Q/L}{C/N} = \frac{N}{L} = \frac{\sum_i N_{\eta}^{(i)}}{\sum_i L_{\eta}^{(i)}} = \frac{\boldsymbol{\eta}^T \mathbf{M} \mathbf{c}}{\boldsymbol{\eta}^T \mathbf{c}} \tag{2.20}$$

while the disaggregated index for each vertically hyper-integrated sector i

is:[12]

$$\beta^{(i)} = \frac{c_i / L_\eta^{(i)}}{c_i / N_\eta^{(i)}} = \frac{N_\eta^{(i)}}{L_\eta^{(i)}} = \frac{\boldsymbol{\eta}^T \mathbf{m}_i c_i}{\eta_i c_i} = \frac{\boldsymbol{\eta}^T \mathbf{m}_i}{\eta_i} \tag{2.21}$$

The aggregate measure is obtained starting from Pasinetti's (1959) original formulation, but computing N and L consistently with the vertically hyper-integrated framework exposed above. In this way, the major shortcoming of the original measure — i.e. that of depending on nominal, rather than physical, magnitudes — is overcome. The fact of co-moving with the capital/wages — rather than with the capital/output — ratio was a direct consequence on the way in which N and L were estimated, and therefore this shortcoming is overcome by the present formulation too.

As to the sectoral indexes, their formulation is the obvious extension of the aggregate one. Clearly, this extension is straightforward once input-output data are used. Moreover, it is worth stressing that while the aggregate measure also depends on the composition of demand, and thus its movements through time also depend on changes in such a composition, the sectoral indexes are intrinsically technical, since they are independent of the structure of consumption.

[12] It is straightforward to show that the absolute level of both measures can be computed starting from nominal magnitudes, since the effect of prices cancels out:

$$\frac{\boldsymbol{\eta}^T \widehat{\mathbf{p}}_s^{-1} \widehat{\mathbf{p}}_s \mathbf{M} \widehat{\mathbf{p}}_s^{-1} \widehat{\mathbf{p}}_s \mathbf{c}}{\boldsymbol{\eta}^T \widehat{\mathbf{p}}_s^{-1} \widehat{\mathbf{p}}_s \mathbf{c}} = \frac{\boldsymbol{\eta}^T \mathbf{M} \mathbf{c}}{\boldsymbol{\eta}^T \mathbf{c}} = \beta^*$$

$$\frac{\boldsymbol{\eta}^T \widehat{\mathbf{p}}_s^{-1} \widehat{\mathbf{p}}_s \mathbf{m}_i p_i^{-1}}{\eta_i p_i^{-1}} = \frac{\boldsymbol{\eta}^T \mathbf{m}_i}{\eta_i} = \beta^{(i)}$$

3 An empirical exploration

Having derived a set of sectoral and aggregate computable measures of productivity increase and direction of technical change, this section reports the results of their empirical application to study the Italian economy during 1999-2007. Data has been obtained from the Italian National Institute of Statistics (ISTAT).

In particular, after singling out some aggregate features of the process of technological development (section 3.1), a more detailed analysis at the sectoral level is performed (sections 3.2 and 3.3) and, finally, a comparison between hyper-integrated labour productivity changes and (Input-Output) Total Factor Productivity Growth (TFPG) is reported (section 3.4).

3.1 Aggregate Trends

Tables 2 and 3 display levels and rates of change, respectively, of selected aggregate variables for the period 1999-2007. Their description is given in Table 1.

For the aim of analysing co-movement trends among variables, the full period 1999-2007 is divided into three sub-periods: 1999-2000, 2000-2003 and 2003-2007. The first two years are presumably the end of a trend that comes from previous years, the 2000-2003 sub-period is characterised by negative productivity growth (as measured by ρ^*, and computed according to (2.19)), while the contrary occurs in the final 2003-2007 sub-period.

The transition between 1999 and 2000 is characterised by the highest values for ρ^* (2.46 p.p.) and ρ_{tfp} (1.76 p.p.) of the whole period, i.e. high productivity growth and increasing surplus from the value added side. This has been accompanied by a mild decrease in the wage share Ω_W *and* real wage rate $w/\overline{c}_p^*$, together with the highest increase in employment (1.80 p.p.) between 1999 and 2007.

Moreover, note that the ratio of the money wage rate to the price of the average consumption basket (w/c_p^*) experiences a decrease (from 1.88 to 1.83). Thus, given that the money wage rate and employment are increasing, this must be due to the rising consumption per-capita.

The sub-period 2000-2003 is characterised by negative productivity growth as well as a decrease in the real wage rate though accompanied by a mild increase in the wage *share*. The ratio of the money wage to average per-capita consumption remains constant with a rising money wage rate and employment, indicating an increase in nominal per-capita (average) consumption.

Table 1: Selected Variables, Description

variable	title
L	Units of Labour
W/L	Money Wage Rate
Ω_W	Wage Share
w/c_p^*	Wage rate to price of average consumption basket
S^*/W	Capacity to Wages Ratio
S^*/C	Capacity to Domestic Final Consumption Ratio
β^*	Aggregate Capital Intensity
$\Delta\%L$	Units of Industry Labour Growth
$\Delta\%(w/\bar{c}_p^*)$	Growth of Wage Rate to fixed per-capita Private Consumption Ratio
ρ_{tfp}	TFP growth rate
ρ^*	Standard rate of productivity growth
$\Delta\%\beta^*$	Aggregate Direction of Technical Change

Source: Own computation based on Supply-Use Tables (SUT) and National Accounts Data, ISTAT

Table 2: Selected Aggregate Level Variables, Italy (1999-2007)

variable	units	1999	2000	2001	2002	2003	2004	2005	2006	2007	mean
L	(th.ULE)	22994.70	23412.30	23828.60	24132.20	24282.90	24373.00	24411.60	24788.70	25026.40	24138.93
W/L	(mln.MU/th.ULE)	20.26	20.86	21.59	22.15	22.86	23.64	24.45	25.22	25.82	22.98
Ω_W	(%)	46.34	45.90	45.82	45.86	46.11	46.02	46.47	47.20	46.73	46.27
w/c_p^*		1.88	1.83	1.82	1.82	1.82	1.85	1.86	1.87	1.86	1.85
S^*/W			14.37	14.33	14.54	14.63	14.90	15.16	15.18	15.46	14.82
S^*/C			6.31	6.33	6.51	6.61	6.70	6.76	6.74	6.78	6.59
β^*			6.37	6.42	6.58	6.67	6.67	6.80	6.78	6.87	6.64

Source: Own computation based on Supply-Use Tables (SUT) and National Accounts Data, ISTAT

Table 3: Selected Aggregate Variables, Rates of Change, Italy (1999-2007)

variable	units	99-00	00-01	01-02	02-03	03-04	04-05	05-06	06-07	mean
$\Delta\%L$	(pp)	1.80	1.76	1.27	0.62	0.37	0.16	1.53	0.95	1.06
$\Delta\%(w/\bar{c}_p^*)$	(pp)	−0.24	0.17	−0.31	−0.40	1.26	1.31	1.06	0.10	0.37
ρ_{tfp}	(pp)	1.76	0.11	−0.83	−1.42	0.73	−0.23	0.46	0.33	0.11
ρ^*	(pp)	2.46	−0.24	−1.27	−0.62	1.69	1.18	0.92	0.82	0.62
$\Delta\%\beta^*$	(pp)		0.92	2.41	1.89	−0.16	2.22	−0.52	1.42	1.17

Source: Own computation based on Supply-Use Tables (SUT) and National Accounts Data, ISTAT

Between 2000 and 2003, capital intensity of the system shows the highest increase of the whole period, either measured at current statistical prices (S^*/C) or by using vertically hyper-integrated labour coefficients as aggregators (β^*), so the direction of technical change has clearly been non-neutral.

The negative trend of productivity growth is reverted in the 2003-2007 sub-period, though experiencing continuous decline. The rhythm of employment creation has also been reduced though the real wage rate has experienced the highest increase of the whole 1999-2007 period during 2003-2006. Real wage increase with mild wage share increase have been accompanied by a rising trend in the ratio of money wage rate to per-capita average consumption. Technical change has been capital intensity-increasing (both S^*/C and β^* have risen), though to a lesser extent than during 2000-2003.

It is interesting to ask to what extent productivity increases (as measured by ρ^*) have accrued to real wage growth (as measured by $\Delta\%(w/\bar{c}_p^*)$). For the whole 1999-2007 period, ρ^* has exceeded $\Delta\%(w/\bar{c}_p^*)$ by a yearly average of 0.25 p.p., though it is interesting to notice that when productivity is falling (2000-2003), the real wage decreases to a lesser extent (their yearly average difference is -0.53 p.p.). Hence, productivity movements amplify those of the real wage rate in both directions, though the overall trend suggests that only 60% of productivity growth accrues to wages, on average.

Finally, it emerges from Table 3 that when Pasinetti's (1959) original measure β is replaced by β^* (as defined in (2.20)), its co-movement and order of magnitude clearly resembles the ratio S^*/C of total capacity (domestically produced plus imported) to net output (of the growing subsystem).[13]

3.2 Industry/Subsystem Trends

The structure of the economic system by industry, vertically integrated and vertically hyper-integrated sectors

Tables 16, 17 and 18 in Appendix A display the percentage distribution of labour by industry, vertically integrated (VI, hereinafter) sector and vertically hyper-integrated (VHI, hereinafter) sector, respectively. The first conclusion that can be drawn by looking at these tables is that, whatever the repartition of economic activities, the structure of employment (at this aggregation level) has not undergone radical changes. Therefore, Table 4 reports the average values (across years) for the whole 1999-2007 period.

It is interesting to compare the distribution of labour among different activities when industries, VI sectors and VHI sectors are alternatively adopted as the unit of analysis, as displayed in columns (1), (2) and (3) of Table 4.

[13] Their correlation coefficient between 2000 and 2007 is 0.978.

Table 4: Employment/Labour (re)distribution by Industry/Subsystem, Italy (average 1999-2007), (1)-(3) in average % and (4) in yearly average percentage points (p.p.)

	L_j/L (1)	$L_\nu^{(i)}/L$ (2)	$L_\eta^{(i)}/L$ (3)	$L_\eta^{(i)}/L - L_j/L$ (4)
AA:Agriculture	5.65	1.49	1.92	−3.73
BB:Fishing	0.24	0.19	0.19	−0.05
CB:Mining non-energy	0.14	0.03	0.03	−0.10
DA:Food-Tobacco	1.92	5.35	5.72	3.80
DB:Textiles	2.48	3.62	3.75	1.27
DC:Leather	0.80	1.24	1.32	0.52
DD:Wood	0.75	0.19	0.19	−0.56
DE:Paper-Printing	1.11	0.88	0.98	−0.13
DF:Coke-Petroleum	0.11	0.21	0.29	0.18
DG:Chemicals	0.86	1.30	1.43	0.57
DH:Plastics	0.86	0.59	0.67	−0.19
DI:Non-met. minerals	1.06	0.67	0.70	−0.36
DJ:Metals	3.52	1.78	1.78	−1.73
DK:Machinery n.e.c.	2.50	4.18	3.87	1.36
DL:Electr. Machinery	1.88	1.81	1.54	−0.33
DM:Transport Equip.	1.12	1.79	1.84	0.72
DN:Manufacture n.e.c.	1.31	1.85	1.92	0.60
EE:Energy	0.56	0.58	0.73	0.17
FF:Construction	7.38	7.97	0.63	−6.75
GG:Trade	14.48	15.41	16.03	1.55
HH:Hotel-Restaurant	5.69	7.28	7.87	2.19
II:Transport-Comm.	6.52	4.94	5.42	−1.10
JJ:Finance	2.49	1.51	1.58	−0.91
KK:Business Services	10.73	6.90	8.81	−1.92
LL:Public Admin.	5.85	7.69	9.20	3.35
MM:Education	6.54	6.56	6.76	0.23
NN:Health	6.10	7.45	7.91	1.80
OO:Personal Services	4.07	3.27	3.64	−0.44
PP:Household Services	3.28	3.26	3.28	0.00

Source: Own computation based on Supply-Use Tables (SUT) and National Accounts Data, ISTAT

In doing so, it is important to keep in mind that in the first case we are considering as output those *composite commodities* jointly produced by the various industries, while in the latter two cases we are considering the *single commodities* produced as the main output by the corresponding industry.

In all three cases, it is possible to note that six industries/subsystems account for about 50% of total labour. The results are summarised in the first part of Table 5.

On a first inspection of Table 5, we can see that the concentration of labour in the first six activities is higher at the VI sector- rather than at the

Table 5: Labour distribution: Industry-level, VIS-level and VHIS-level (Italy, average 1999-2007)

Pos.	Industry	Cum. %	VI sector	Cum. %	VHI sector	Cum. %
1	*GG:Trade*	14.48	*GG:Trade*	15.41	*GG:Trade*	16.03
2	*KK:Business Services*	25.21	*FF:Construction*	23.38	*LL:Public Admin.*	25.23
3	*FF:Construction*	32.59	*LL:Public Admin.*	31.07	*KK:Business Services*	34.04
4	*MM:Education*	39.13	*NN:Health*	38.52	*NN:Health*	41.95
5	*II:Transport-Comm.*	45.65	*HH:Hotel-Restaurant*	45.80	*HH:Hotel-Restaurant*	49.82
6	*NN:Health*	51.75	*KK:Business Services*	52.70	*MM:Education*	56.58

Source: Table 4.

Activity	% as Industry	% as VI sector	% as VHI sector
FF:Construction	7.38	7.97	0.63
DA:Food-Tobacco	1.92	5.35	5.36
AA:Agriculture	5.65	1.49	1.92

Source: Table 4.

industry-level, and further increases when VHI sectors are chosen as unit of analysis.

Activities *GG:Trade*, *KK:Business Services* and *NN:Health* are present in all three cases, though in different positions (with the exception of *GG:Trade* which is always the most important activity). If we extended our table to include the first eight — rather than six — positions, *LL:Public Admin.*, *HH:Hotels-Restaurant* and *MM:Education* would also be among the most important activities in all three cases.

The only, though very sharp, difference is represented by *FF:Construction*, which is one of the main industries as well as VI sectors (with a very similar relative importance). However, when looking at Table 4, we can see that it is a very small VHI sector, employing only 0.63% of total labour. From this we infer that *FF:Construction* is an activity employing mostly direct labour, which explains the similarity when looked at as an industry and as a VI sector, and that almost all of its output consists of means of production used by other activities. This result is particularly interesting. Were we to use the present analysis to evaluate, for example, the opportunity of public investment aiming at sustaining employment in the economic system, a traditional inter-industry analysis would lead us to conclude that by investing in this sector it would be possible to give rise to a number of backward linkages in the economic system as a whole. On the contrary, stating the analysis in VHI terms allows us to see that this would not be an adequate conclusion.

Moreover, there are two further activities characterised by a relevant change in their relative position when the unit of analysis is changed (as can be seen in the second part of Table 5). The first one is *DA:Food-Tobacco*, which increases considerably its labour participation when seen as a (growing) subsystem instead of as an industry. This clearly means that it is a subsystem which absorbs labour from other activities, and thus has a strong indirect labour component.[14]

The second one is *AA:Agriculture*, which is in an opposite situation: it is much more important when looked at as an industry than as a (growing) subsystem. This means that a considerable part of the gross output of the corresponding industry is used as intermediate commodities by other activities (e.g. *DA:Food-Tobacco*).

Finally, there are three VHI sectors that changed in an apparent way their relative weight in labour distribution during the period as a whole: *KK:Business Services* (increasing from 7.91 to 9.62%); *DB:Textiles* (decreasing from 4.19 to 3.11%); and *DN:Manufacture n.e.c.* (declining from 2.19 to 1.63%).

Redistribution of labour between industry and growing subsystem

Table 19 in Appendix A reports the yearly redistribution of labour that takes place when the unit of analysis is switched from the industry to the growing subsystem. Moreover, column (4) of Table 4 displays the mean value for the whole 1999-2007 period. Due to the stable character of redistribution patterns through time, we focus on the average value across years.

Given the different output concept to which industry and subsystem labour refer to, the same total employment L is redistributed in the logical operation of hyper-integration, partitioning the system into as many parts as there are final commodities. Hence, $L_\eta^{(i)}$ reflects the total labour required to reproduce a unit of commodity i for final uses, this labour coming both from the industries directly producing it and from all the supporting industries providing inputs for them.

Redistribution patterns allow to identify which growing subsystems mainly provide ($L_\eta^{(i)} - L_j < 0, j = i$) or absorb ($L_\eta^{(i)} - L_j > 0, j = i$) labour, as well as to see the importance of backward linkages exerted by final industries to all their supporting industries.

As can be read from column (4) of Table 4, the transformation of natural resources and primary products into manufactured commodities implies a crucial absorption of labour by subsystems like *DA:Food-Tobacco* and

[14] See below, at the end of this section, the analysis of labour redistribution between industries and subsystems, focusing on column (4) of Table 4.

DB:Textiles. Moreover, note the dimension of subsystem *LL:Public Admin.* as a demander of commodities through its backward linkages.

Three important service subsystems (*HH:Hotel-Restaurant*, *NN:Health* and *GG:Trade*) are among those with highest absorption of labour (together adding to 5.54 p.p.). As to manufacturing, *DK:Machinery n.e.c.* (mainly mechanical machinery), *DM:Transport Equip.* (the automobile complex), *DN:Manufacture n.e.c.* (which includes furniture) and *DG:Chemicals* (which includes pharmaceutical products) are among the most relevant growing subsystems as regards labour absorption.

In contradistinction, the most important provider of labour is clearly *FF:Construction*, given that (almost) all its output goes to increase the productive capacity of the different growing subsystems. As a reflection of the industrialization of primary products *AA:Agriculture* is a crucial provider of labour.

More interesting is the case of service subsystems like *KK:Business Services*, *II:Transport-Comm.* and *JJ:Finance*, which together add to -3.93 p.p., and suggests that the demand they exert through backwards linkages to other industries is offset by their role as provider of standardised services to all other industries (including themselves). Moreover, among manufacturing subsystems *DJ:Metals* is the most important provider of labour through the intermediate (circulating and fixed) capital inputs it sells to other industries, assuming a role of crucial provider of intermediate inputs economy-wide.

Employment and gross output dynamics by industry

Table 20 in Appendix A reports year-by-year industry employment dynamics ($\Delta\%L_j$) and gross output growth by commodity ($\Delta\%q_i$) during the considered period. Moreover, columns (1)-(2) of Table 6 display yearly average values for these variables across years.

On a yearly average basis, the five industries with highest increase in employment are *KK:Business Services* (3.70 p.p.), *FF:Construction* (2.98 p.p.), *PP:Household services* (2.86 p.p.), *HH:Hotel-Restaurant* (2.50 p.p.) and *OO:Personal Services* (1.97 p.p.).

By looking more in detail the year-by-year performance of the three main activities (as displayed in Table 20 of Appendix A), it emerges that *KK:Business Services* started from an important increase in the first period (1999-2000, 7.17 p.p.), progressively slowed down up to 2004-2005 (1.34 p.p.) and then accelerated again until the end of the period, though being far away from the initial value (2.98 p.p. in 2006-2007). Employment in *HH:Hotel-Restaurant* also increased considerably in the first period (7.75 p.p.), then slowed down, though being still quite sustained, up to 2003-2004, experiencing very modest increases (around 0.30 p.p. yearly) in the last four years. Finally, *FF:Construction* did not show a definite trend, with employment displaying an oscillating behaviour, with its minimum in 2005-2006 (1.20 p.p.) and its maximum in 2000-2001 (2.98 p.p.).

The five industries that, on the contrary, saw the greatest decline in their employment on a yearly average basis are *DC:Leather* (-2.87 p.p.), *DB:Textiles* (-2.47 p.p.), *AA:Agriculture* (-1.70 p.p.), *DD:Wood* (-1.51 p.p.) and *DH:Plastics* (-1.37 p.p.).

Column (2) of Table 6 conveys information about changes in gross output by commodity, which can be compared to that regarding employment dynamics. The result is that *PP:Household services* is the only industry that is among the five most dynamics activities as regards both employment and output growth; on the contrary, four of the industries with worst employment performance are also among the five industries whose output declined the most: *DC:Leather* (-2.87 p.p.), *DB:Textiles* (-2.47 p.p.), *AA:Agriculture* (-1.70 p.p.) and *DH:Plastics* (-1.37 p.p.).

VI and VHI labour productivity dynamics

Tables 21 and 22 in Appendix A report year-by-year dynamics of VI and VHI labour productivity ($\Delta\%\alpha_\nu^{(i)}$ and $\Delta\%\alpha_\eta^{(i)}$, respectively) together with the corresponding net output growth ($\Delta\%y_i$ and $\Delta\%c_i$, respectively). Moreover, Tables 23 and 24 in Appendix A report changes in *total* labour at the VI and VHI sector level ($\Delta\%L_\nu^{(i)}$ and $\Delta\%L_\eta^{(i)}$, respectively). Additionally, mean values across years for each of these variables are reported in columns (3)-(8) of Table 6. When looking at year-by-year changes, recall that for each VI/VHI sector i, respectively:

$$\Delta\%L_\nu^{(i)} = \Delta\%y_i - \Delta\%\alpha_\nu^{(i)} \tag{3.1}$$

$$\Delta\%L_\eta^{(i)} = \Delta\%c_i - \Delta\%\alpha_\eta^{(i)} \tag{3.2}$$

Expression (3.1) is a 'spurious' decomposition: changes in y_i are due to changes in both final demand for consumption commodities and for new investment goods. But the process of reproduction of capital goods is itself subject to technical change, so that changes in vertically integrated net output are also influenced by changes in productivity, i.e. by the second addendum of the decomposition. On the contrary, expression (3.2) correctly separates the effect of changes in the composition of effective demand for final uses from the effects of technical progress on total subsystem employment, thereby separating what re-enters from what does not re-enter the circular flow. Hence, it is $\Delta\%L_\eta^{(i)}$ that displays the structural dynamics of employment as intended by Pasinetti (1981, pp. 94-7).

Table 6: Dynamics of (Net) Output, Employment, (Growing) Subsystem Labour Productivity, and VHI Decomposition for Italy (mean values over 1999-2007), in yearly average percentage points (p.p.)

	$\Delta\%L_j$ (01)	$\Delta\%q_i$ (02)	$\Delta\%L_{\nu}^{(i)}$ (03)	$\Delta\%y_i$ (04)	$\Delta\%\alpha_{\nu}^{(i)}$ (05)	$\Delta\%L_{\eta}^{(i)}$ (06)	$\Delta\%c_i$ (07)	$\Delta\%\alpha_{\eta}^{(i)}$ (08)	$\Delta\%\alpha_{\eta,d}^{(i)}$ (09)	$\Delta\%\alpha_{\eta,hy}^{(i)}$ (10)	$\omega_{\eta,d}^{(i)}$ (11)
AA:Agriculture	−1.70	−0.42	−17.53	−19.96	−2.43	1.17	2.01	0.84	1.20	−0.07	70.89
BB:Fishing	−0.44	−1.32	4.90	−0.69	−5.59	3.60	2.46	−1.14	−0.80	−2.53	81.64
CB:Mining non-energy	−1.91	−0.40	1.24	−3.52	−4.76	1.68	2.08	0.40	1.69	−0.46	40.03
DA:Food-Tobacco	0.16	1.14	1.32	0.21	−1.12	2.14	4.23	2.08	1.37	2.25	18.60
DB:Textiles	−2.47	−1.38	−2.53	−2.33	0.20	−0.69	1.12	1.81	1.17	2.37	46.28
DC:Leather	−2.87	−1.05	−4.12	−3.77	0.35	−1.64	0.37	2.01	2.57	1.69	38.05
DD:Wood	−1.51	0.18	−6.06	−5.32	0.74	−2.29	0.53	2.82	2.02	3.53	47.72
DE:Paper-Printing	−0.54	1.49	0.53	−0.23	−0.75	1.18	2.40	1.22	1.46	1.07	37.70
DF:Coke-Petroleum	0.00	0.01	8.15	−2.92	−11.07	5.71	−1.36	−7.07	−1.98	−8.35	18.44
DG:Chemicals	−0.47	0.21	2.22	5.12	2.90	1.22	4.45	3.23	1.13	4.03	27.40
DH:Plastics	−1.37	−0.15	1.99	3.76	1.78	2.00	3.92	1.92	1.90	1.95	40.11
DI:Non-met. minerals	0.37	1.88	−4.34	−4.23	0.10	−0.59	0.44	1.03	1.35	0.83	38.25
DJ:Metals	1.43	2.39	5.77	6.18	0.40	5.58	6.46	0.89	1.15	0.70	42.47
DK:Machinery n.e.c.	1.51	3.29	1.49	2.03	0.54	0.82	2.85	2.03	1.32	2.42	36.10
DL:Electr. Machinery	1.12	2.12	−1.98	−1.11	0.86	−0.12	1.95	2.07	1.41	2.64	46.02
DM:Transport Equip.	−0.45	0.80	−2.20	−2.74	−0.53	1.15	2.63	1.49	3.23	0.83	26.89
DN:Manufacture n.e.c.	−0.50	0.16	−2.31	−3.11	−0.80	−1.36	0.01	1.37	0.61	1.89	41.56
EE:Energy	−1.41	1.99	4.82	3.87	−0.95	1.57	0.95	−0.62	2.74	−1.56	20.89
FF:Construction	2.98	2.36	2.17	1.02	−1.15	−0.57	−0.64	−0.07	−0.68	0.57	50.67
GG:Trade	0.68	1.68	0.96	0.39	−0.57	0.97	1.09	0.11	1.13	−0.97	50.99
HH:Hotel-Restaurant	2.50	1.60	2.74	0.42	−2.33	2.33	1.92	−0.41	−1.11	0.52	57.38
II:Transport-Comm.	1.31	3.66	−0.33	0.02	0.36	1.63	3.15	1.52	2.39	0.87	41.84
JJ:Finance	0.86	3.60	1.09	1.73	0.63	1.76	3.49	1.73	2.71	0.74	50.00
KK:Business Services	3.70	2.37	2.39	0.20	−2.19	2.82	1.35	−1.47	−1.31	−1.61	45.47
LL:Public Admin.	−0.86	1.23	0.10	1.36	1.26	−0.18	1.24	1.42	2.09	0.23	62.96
MM:Education	0.47	0.57	0.40	0.56	0.15	0.11	0.57	0.46	0.06	3.68	88.79
NN:Health	1.07	2.32	1.98	2.67	0.68	1.74	2.53	0.78	1.25	−0.42	72.17
OO:Personal Services	1.97	0.13	3.72	2.01	−1.71	3.02	1.48	−1.55	−2.09	−0.76	58.08
PP:Household Services	2.86	2.87	2.88	2.88	0.00	2.86	2.87	0.01	0.01		100.00

Source: Own computation based on Supply-Use Tables (SUT) and National Accounts Data, ISTAT

Given that VI and VHI labour productivity changes crucially depend on employment trends, it is useful to draw conclusions on the basis of the joint dynamics of labour productivity and total labour by VI and VHI sector, respectively. By combining positive and negative values for each variable, four typologies can be distinguished. The results of such an inspection are summarised in Table 7.

Table 7: Activity classification by the joint dynamics of labour productivity and total labour by VI and VHI sectors (average values for 1999-2007)

	Vertically integrated (VI) sectors	
	$\Delta\% L_{\nu}^{(i)} > 0$	$\Delta\% L_{\nu}^{(i)} < 0$
$\Delta\% \alpha_{\nu}^{(i)} > 0$	DG, DH, DJ, DK, JJ, LL, MM, NN, PP	DB, DC, DD, DI, DL
$\Delta\% \alpha_{\nu}^{(i)} < 0$	BB, CB, DA, DE, DF, EE, FF, GG, HH, KK, OO	AA, DM, DN
	Vertically hyper-integrated (VHI) sectors	
	$\Delta\% L_{\eta}^{(i)} > 0$	$\Delta\% L_{\eta}^{(i)} < 0$
$\Delta\% \alpha_{\eta}^{(i)} > 0$	AA, CB, DA, DE, DG, DH, DJ, DK, DM, GG, II, JJ, MM, NN, PP	DB, DC, DD, DI, DL, DN, LL
$\Delta\% \alpha_{\eta}^{(i)} < 0$	BB, DF, EE, HH, KK, OO	FF

Source: Table 6.

The activities in the upper-left quadrant in each tabulation of the Table correspond to 'virtuous' sectors: they are characterised by increasing labour productivity *and* employment. The ones in the bottom-left quadrant, on the contrary, are 'vicious' sectors: they saw a decrease of both labour productivity and employment. Then, we have those activities which increased productivity but decreased employment, at the bottom-right quadrant, and those where the opposite has occurred, in the upper-left one.

Let us start by analysing the dynamics of *vertically integrated* labour productivity. As can be seen from Table 7, there are nine 'virtuous' and three 'vicious' VI sectors. The virtuous ones include diffused intermediate inputs like *DG:Chemicals* and *DH:Plastics*, as well as the metals-mechanical machinery complex (*DJ:Metals* and *DK:Machinery n.e.c.*). As to services, we have *JJ:Finance*, *LL:Public Admin.*, *MM:Education*, *NN:Health* and *PP:Households Services*, two of which (*LL:Public Admin.* and *NN:Health*) are also among the most important as to their share in total employment. Altogether, on average, these nine subsystems account for 34.68% (37.25% in 2000, 38.17% in 2006) of total employment. Instead, the three vicious sectors are *AA:Agriculture*, *DM:Transport Equip.* and *DN:Manufacture n.e.c.*, which, on average, account for 5.13% of total employment (5.50% in 2000, 3.82% in

2006).

Let us now look at *vertically hyper-integrated* labour productivity (second tabulation of Table 7). In this case, there is only one vicious sector (*FF:Construction*) and 15 virtuous ones, which altogether accounted for 63.95% (in 1999) and 63.05% (in 2007) of total employment (62.97% on average). Some virtuous growing subsystems are virtuous in VI terms as well (DG, DH, DJ, DK, JJ, MM, NN and PP); while *AA:Agriculture* and *DM:Transport Equip.* are instead classified as vicious VI sectors. This suggests that the increase in employment and productivity in the production of new investment goods in these growing subsystems was strong enough as to counterbalance the opposite trend in the reproduction of the vertically integrated net product.

However, besides looking at the dynamics of labour productivity as a single magnitude, it would also be informative to decompose each vertically hyper-integrated labour coefficient into a direct and an (hyper-) indirect component. In order to do so, note that from the definition of $\boldsymbol{\eta}^T$ in (2.13), it is possible to obtain for each final commodity i:

$$\eta_i = \boldsymbol{\eta}^T \mathbf{e}_i = \mathbf{l}^T \mathbf{V}_q^{-1} \mathbf{e}_i + \mathbf{l}^T \mathbf{V}_q^{-1} (\mathbf{U}_q + \mathbf{F}_{k_q})(\mathbf{V}_q - \mathbf{U}_q - \mathbf{F}_{k_q})^{-1} \mathbf{e}_i \tag{3.3}$$

where each addendum in the RHS of the equation may be defined as:

$$\eta_d^{(i)} \equiv \mathbf{l}^T \mathbf{V}_q^{-1} \mathbf{e}_i$$
$$\eta_{hy}^{(i)} \equiv \mathbf{l}^T \mathbf{V}_q^{-1} (\mathbf{U}_q + \mathbf{F}_{k_q})(\mathbf{V}_q - \mathbf{U}_q - \mathbf{F}_{k_q})^{-1} \mathbf{e}_i$$

The first addendum ($\eta_d^{(i)}$) represents the direct labour employed by all industries producing commodity i, while the second addendum ($\eta_{hy}^{(i)}$) stands for the indirect and hyper-indirect labour requirements to reproduce a unit of commodity i for final uses.

Accordingly, define $\alpha_{\eta,d}^{(i)} = 1/\eta_d^{(i)}$ and $\alpha_{\eta,hy}^{(i)} = 1/\eta_{hy}^{(i)}$, and by noting that $\alpha_\eta^{(i)} = 1/\eta_i$ so that $d \ln \alpha_\eta^{(i)} = -d \ln \eta_i = -d \ln(\eta_d^{(i)} + \eta_{hy}^{(i)})$ it is possible to write for each growing subsystem i:

$$d \ln \alpha_\eta^{(i)} = \omega_{\eta,d} d \ln \alpha_{\eta,d}^{(i)} + (1 - \omega_{\eta,d}) d \ln \alpha_{\eta,hy}^{(i)} \tag{3.4}$$

where $\omega_{\eta,d} = \eta_d^{(i)}/\eta_i$, i.e. the share of direct labour in total vertically hyper-integrated labour per unit of net output.

In terms of a first order approximation, expression (3.4) becomes:

$$\Delta\%\alpha_\eta^{(i)} = \omega_{\eta,d} \Delta\%\alpha_{\eta,d}^{(i)} + (1 - \omega_{\eta,d}) \Delta\%\alpha_{\eta,hy}^{(i)} \tag{3.5}$$

Hence, it is possible to explore to what extent the total change in hyper-integrated labour productivity ($\Delta\%\alpha_{\eta}^{(i)}$) is due to a direct labour saving effect ($\Delta\%\alpha_{\eta,d}^{(i)}$) or to an (hyper-) indirect effect ($\Delta\%\alpha_{\eta,hy}^{(i)}$), weighted by the importance of direct labour within each growing subsystem ($\omega_{\eta,d}$).

Table 25 in Appendix A reports the decomposition of hyper-integrated labour productivity changes into its direct and (hyper-) indirect components, together with the share $\omega_{\eta,d}$, for selected years (1999-2000, 2003-2004, and 2006-2007). Additionally, columns (8)-(11) of Table 6 display the mean values across years of these variables.

By using this information, it is possible to classify sectors according to the joint dynamics of these variables, as reported by Table 8.

Table 8: Activity classification by the joint dynamics of direct and (hyper-) indirect components of productivity changes (average values for 1999-2007)

	$\Delta\omega_{\eta,d}^{(i)} > 0$		$\Delta\omega_{\eta,d}^{(i)} < 0$	
	$\Delta\%\alpha_{\eta,d}^{(i)} > 0$	$\Delta\%\alpha_{\eta,d}^{(i)} < 0$	$\Delta\%\alpha_{\eta,d}^{(i)} > 0$	$\Delta\%\alpha_{\eta,d}^{(i)} < 0$
$\Delta\%\alpha_{\eta,hy}^{(i)} > 0$	DG, DD, DA, DL, DK, DB, DN, DE, MM	FF,HH	DC, DH, JJ, II, DM, LL, DI, DJ	
$\Delta\%\alpha_{\eta,hy}^{(i)} < 0$		BB, KK, OO	AA, NN, CB, GG, EE	DF

Source: Table 25 in Appendix A.

Among sectors with an increasing direct component, nine had an overall increase in productivity, i.e. both their direct and the indirect components grew. As to the two subsystems with increasing indirect and decreasing direct productivity (*FF:Construction* and *HH:Hotel-Restaurant*), in both cases the negative direct effect prevailed, so that total VHI labour productivity was decreasing. The last three sectors with increasing direct component had a decreasing VHI productivity (*BB:Fishing*, *KK:Business Services* and *OO:Personal Services*). No sector was characterised by an increasing direct productivity together with a decreasing indirect one.

Among sectors with a decreasing direct component, eight saw an overall increase in VHI productivity, and only one (*DF:Coke-Petroleum*) a decrease. No sector is characterised by decreasing direct productivity and increasing indirect one. On the contrary, five sectors behaved in the opposite way. Among them, four (*AA:Agriculture*, *NN:Health*, *CB:Mining non-energy* and *GG:Trade*) had an increasing overall productivity, and only *EE:Energy* a decreasing one.

3.3 Capital intensity and direction of technical change

As has been emphasized by Pasinetti himself "[i]ndirectness or roundaboutness of a production process clearly refers to a relation between stocks and flows" (Pasinetti 1981, p. 180). In this sense, capital intensity, as given by β^* (computed according to (2.20)) for the economy as a whole or by $\beta^{(i)}$ (computed according to (2.21)) for each growing subsystem, is the proposed measure to analyse the direction of technical change.[15]

Table 10 reports year-by-year levels of $\beta^{(i)}$ for each growing subsystem, together with the mean value across years and the absolute difference between the first (2000) and last (2007) year.

It is interesting to analyse data on capital intensity jointly with VHI labour productivity. A subdivision into four typologies according to the sign of their joint dynamics is displayed in Table 9.

Table 9: Activity classification according to capital intensity and productivity changes.

	$\Delta\beta^{(i)} > 0$	$\Delta\beta^{(i)} < 0$
$\Delta\%\alpha_{\eta}^{(i)} > 0$	AA, CB, DA, DB, DC, DD, DE, DG, DH, DI, DJ, DK, DL, DM, DN, GG, II, JJ, LL, MM, NN	
$\Delta\%\alpha_{\eta}^{(i)} < 0$	DF, FF, HH, OO	BB, EE, KK

Source: Tables 6 and 10.

As to the direction of technical change, by inspecting Table 9, we notice that only three sectors experienced a decrease in capital intensity — i.e. capital saving technical change[16] — namely *BB:Fishing*, *EE:Energy* and *KK:Business Services*. The remaining 26 sectors saw an increase in $\beta^{(i)}$, ranging from +0.03 (*OO:Personal Services*) to +3.29 (*DF:Coke-Petroleum*).[17]

Moreover, the three sectors with decreasing capital intensity also saw a decrease in VHI labour productivity. On the contrary, only four of the sectors with an increasing $\beta^{(i)}$ had a decreasing productivity — namely, *DF:Coke-Petroleum*, *FF:Construction*, *HH:Hotel-Restaurant* and *OO:Personal Services*. All the others have been characterised by increasing capital intensity and VHI labour productivity.

[15]Instead, the capital labour ratio cannot be taken as an index of capital intensity given that, for example, it depends on the standard of value chosen to close the price system with which capital inputs are aggregated (for details, see Pasinetti 1981, p. 182).

[16]By capital saving we mean that the vertically hyper-integrated labour required to reproduce the stock of productive capacity decreases relatively to that required to reproduce the net output, consistently with our contention that technical progress is ultimately always labour saving.

[17]Excluding *PP:Household services* which only employs direct labour.

Table 10: Capital Intensity, Italy - $\beta^{(i)}$

act	2000	2001	2002	2003	2004	2005	2006	2007	mean	$\beta^{(i)}_{07} - \beta^{(i)}_{00}$
KK:Business Services	16.66	16.15	15.94	16.01	15.80	15.88	15.77	15.89	16.01	−0.77
EE:Energy	15.94	15.45	15.66	15.20	16.15	16.06	16.10	15.79	15.79	−0.15
DF:Coke-Petroleum	9.49	10.31	11.41	11.35	11.03	11.87	13.98	12.78	11.53	3.29
LL:Public Admin.	9.86	9.95	10.23	10.55	10.55	10.95	11.07	11.44	10.57	1.58
CB:Mining non-energy	9.31	9.28	9.11	9.48	9.30	9.25	9.64	9.71	9.38	0.40
DG:Chemicals	9.26	9.46	9.25	9.63	9.35	9.45	9.38	9.29	9.38	0.04
DH:Plastics	7.06	7.09	7.25	7.54	7.63	7.81	7.78	7.86	7.50	0.80
DM:Transport Equip.	7.04	7.28	7.61	7.95	7.61	7.55	7.35	7.33	7.47	0.30
DI:Non-met. minerals	6.90	6.91	7.08	7.33	7.37	7.39	7.51	7.51	7.25	0.61
DE:Paper-Printing	6.78	6.93	7.08	7.20	7.17	7.30	7.27	7.34	7.14	0.56
II:Transport-Comm.	6.63	6.71	6.87	6.97	7.06	7.12	7.13	7.16	6.96	0.53
DA:Food-Tobacco	6.41	6.51	6.74	6.91	6.83	7.00	6.99	7.09	6.81	0.68
JJ:Finance	6.37	6.37	6.71	6.74	6.62	6.76	6.75	6.69	6.63	0.31
DJ:Metals	6.44	6.46	6.60	6.58	6.58	6.67	6.51	6.61	6.55	0.17
DK:Machinery n.e.c.	6.44	6.48	6.64	6.64	6.51	6.53	6.43	6.56	6.53	0.13
DD:Wood	5.70	5.74	5.78	5.90	5.89	6.13	6.02	6.11	5.91	0.41
DB:Textiles	5.54	5.66	5.75	5.78	5.77	5.90	6.01	6.01	5.80	0.47
DN:Manufacture n.e.c.	5.71	5.73	5.82	5.89	5.78	5.79	5.81	5.84	5.80	0.13
DC:Leather	5.32	5.42	5.56	5.60	5.71	5.90	5.95	5.97	5.68	0.65
GG:Trade	5.08	5.20	5.43	5.47	5.54	5.69	5.66	5.76	5.48	0.68
AA:Agriculture	5.01	5.03	5.31	5.55	5.53	5.70	5.62	5.85	5.45	0.84
DL:Electr. Machinery	5.30	5.38	5.59	5.50	5.50	5.41	5.30	5.44	5.43	0.13
OO:Personal Services	5.12	5.12	5.29	5.38	5.24	5.28	5.10	5.15	5.21	0.03
HH:Hotel-Restaurant	4.55	4.62	4.65	4.70	4.66	4.69	4.78	4.86	4.69	0.31
FF:Construction	4.24	4.31	4.48	4.47	4.34	4.33	4.33	4.33	4.35	0.09
NN:Health	2.52	2.57	2.69	2.83	2.87	2.99	3.04	3.11	2.83	0.59
BB:Fishing	2.72	2.73	2.86	3.02	2.90	2.81	2.71	2.63	2.80	−0.10
MM:Education	1.81	1.86	1.92	1.91	1.84	1.94	1.80	1.86	1.87	0.06
PP:Household Services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: Own computation based on Supply-Use Tables (SUT) and National Accounts Data, ISTAT

Given that 22 out of 29 growing subsystems are characterised by increasing productivity and capital intensity, it is interesting to classify sectors according to their average performance in terms of productivity and mean level of capital intensity with respect to their respective aggregate values. Such classification is reported in Table 11.

Table 11: Activity classification according to capital intensity levels and productivity changes.

	$\beta^{(i)} > \beta^*$	$\beta^{(i)} \leq \beta^*$
$\Delta\%\alpha_\eta^{(i)} > \rho^*$	DA, DE, DG, DH, DI, DM, II, LL	AA, DB, DC, DD, DJ, DK, DL, DN, JJ, NN
$\Delta\%\alpha_\eta^{(i)} \leq \rho^*$	CB, DF, EE, KK	BB, FF, GG, HH, MM, OO, PP

Source: Tables 2, 3, 6, and 10.

Among the most dynamic subsystems (i.e. with both changes in productivity and level of capital intensity greater than the corresponding aggregates) we find a most important Italian traditional manufacturing subsystem (*DA:Food-Tobacco*), the Chemical-Pharmaceutical cluster (*DG:Chemicals*), the transport equipment cluster (*DH:Plastics*, which includes rubber tires and *DM:Transport Equip.*) and the information, communication and logistics complex (*DE:Paper-Printing*, *II:Transport-Comm.*).

As to the least dynamic subsystems (i.e. with both changes in productivity and level of capital intensity lower than the corresponding aggregates) we have *FF:Construction*, and an important groups of traditional private services among which the most important is, of course, *GG:Trade*.

As to subsystems with higher than average capital intensity and slower than average productivity dynamics, we have the mining-energy industries (*CB:Mining non-energy*, *DF:Coke-Petroleum* and *EE:Energy*), as well as *KK:Business Services*.

Finally, by considering those subsystems with greater than average productivity growth but lower than average capital intensity, we find a group of natural resources-based sectors (*AA:Agriculture*, *DB:Textiles*, *DC:Leather*, *DD:Wood* and *DN:Manufacture n.e.c.*, which mainly includes furniture), relatively direct labour intensive service subsystems (*JJ:Finance* and *NN:Health*) and the metals-machinery complex (*DJ:Metals*, *DK:Machinery n.e.c.* and *DL:Electr. Machinery*).

At first sight, the metals-machinery complex might seem to be an exception with respect to the other two groups, which are basically employing direct labour. The reason is that the output of this complex (i.e. the denominator of capital intensity) consist itself of capital goods. Moreover, we can notice that, restricting our attention to the machinery complex, productivity growth (2.03 p.p. for *DK:Machinery n.e.c.* and 2.07 p.p. for *DL:Elctr. Machinery*) is much higher than both the standard rate ($\rho^* = 0.62$) and the yearly average real wage rate growth ($\Delta(w/\overline{c}_p^*) = 0.37$). This confirms that[18]

> if, in any production process, at a certain point of time, machines are substituted for labour, the reason simply is that productivity in the machine producing sector is increasing faster than the over-all wage rate. This process, again, is entirely independent of any change in the rate of profit.
>
> (Pasinetti 1981, p. 217)

3.4 Yeast and Mushrooms: hyper-integrated productivity and TFP

From the aggregate dynamics of Table 3 it can be inferred that there exist differences between the standard rate of productivity growth (ρ^*) and (Input-Output) TFP Growth (ρ_{tfp}).Clearly, each of these measures comes from a different theoretical approach to productivity measurement.

In fact, ρ^* is an aggregate measure of *physical* productivity changes obtained from the system of expenditure (i.e. from the nominal counterpart of a set of material product balances), having vertically hyper-integrated labour content at its root. Being derived from a system of physical quantities it only considers commodities domestically produced, as it aims to measure the degree of the division of labour required to reproduce the net output of the system. At its disaggregated level, it refers to the growing subsystem as its unit of analysis.

Instead, ρ_{tfp} is an aggregate measure of the monetary surplus (evaluated in terms of a standard of value) obtained from the value added side of an Input-Output system, which considers only circulating capital inputs as reproducible, with fixed capital being a non-produced primary factor. It considers both domestically produced and imported commodities, as it simply measures the excess of returns over *all* costs (included that of imports). At its disaggregated level, it refers to the industry as its unit of analysis.

Given that traditional 'growth accounting' exercises are performed in terms of TFP Growth[19] it is relevant to make a comparison — at a disaggregated level — between the results obtained by alternative methods.

Consider first Table 12 reporting the absolute difference (i.e. in percentage points) between industry TFP Growth rate ($\rho_{tfp,j}$) and subsystem rate of

[18] See page 49 in section 4 for a discussion of this point.

[19] Note, however, that most treatments do not even consider the reproducible character of intermediate (circulating capital) inputs, given that they depart from a national accounting net income identity, considering industry value added (instead of gross output) as a *physical* measure of disaggregated net product (for details, see Wolff 1994, pp. 77-80).

hyper-integrated labour productivity change ($\Delta\%\alpha_{\eta}^{(j)}$). Results should be interpreted with care given that the unit of analysis in each case differs.

Table 12: Difference between Industry TFPG and Hyper-Subsystem Labour Productivity Growth, Italy - $\rho_{tfp,j} - \Delta\%\alpha_{\eta}^{(j)}$ (pp)

act	99-00	00-01	01-02	02-03	03-04	04-05	05-06	06-07	mean
DF:Coke-Petroleum	0.06	−12.74	6.90	19.29	29.21	7.96	9.31	−16.92	5.38
KK:Business Services	2.08	2.90	2.21	−0.15	0.82	1.81	0.24	0.53	1.30
EE:Energy	−1.18	6.09	2.28	5.22	−12.34	−3.32	0.39	5.36	0.31
PP:Household Services	0.07	0.17	0.06	−0.01	0.26	0.21	0.19	0.21	0.14
OO:Personal Services	0.77	3.05	1.07	−0.27	−5.13	1.08	0.82	−0.26	0.14
FF:Construction	−1.15	0.17	0.81	0.40	−1.21	0.85	−0.68	0.88	0.01
BB:Fishing	−2.09	1.81	1.51	−3.27	1.30	−1.28	0.44	0.68	−0.11
HH:Hotel-Restaurant	−1.23	−0.10	1.52	2.09	0.25	−1.44	−0.64	−1.53	−0.13
JJ:Finance	−1.82	−2.33	1.68	−0.94	1.40	−0.32	0.92	−0.59	−0.25
NN:Health	−0.85	−0.45	−0.51	0.14	0.36	0.24	−0.58	−0.76	−0.30
GG:Trade	−0.53	1.33	0.66	−0.29	−1.09	−2.30	0.12	−0.67	−0.35
MM:Education	0.49	−2.36	−0.19	−0.82	0.08	−0.61	0.15	0.02	−0.41
CB:Mining non-energy	−6.03	−5.13	5.83	−0.63	4.25	1.74	−6.20	1.65	−0.57
DJ:Metals	−3.47	−0.85	1.69	−0.59	−4.50	−0.12	1.51	1.46	−0.61
II:Transport-Comm.	−2.12	−0.42	−1.35	0.43	−0.77	−0.66	−0.45	−0.40	−0.72
AA:Agriculture	−0.12	−0.28	0.24	−2.44	2.89	−5.05	0.11	−1.51	−0.77
DI:Non-met. minerals	−4.59	1.98	2.62	0.08	−2.43	−3.89	−3.12	1.35	−1.00
LL:Public Admin.	−0.87	0.21	0.00	−0.25	−1.42	−2.31	−1.96	−1.69	−1.04
DN:Manufacture n.e.c.	−6.30	−0.42	2.24	0.38	−4.13	0.74	−2.18	−0.82	−1.31
DE:Paper-Printing	−1.36	−2.49	−1.12	−0.48	−2.91	−1.43	−0.52	−0.87	−1.40
DM:Transport Equip.	−6.85	−1.17	−0.95	−0.75	1.80	−0.03	0.01	−3.40	−1.42
DK:Machinery n.e.c.	−4.58	−1.49	2.85	−0.42	−4.46	−1.28	−2.65	−0.19	−1.53
DL:Electr. Machinery	−5.34	0.96	−0.32	0.87	−4.23	−4.09	−1.80	0.01	−1.74
DC:Leather	−9.73	−0.49	4.00	0.83	−5.28	−1.08	−4.03	1.51	−1.78
DB:Textiles	−4.64	0.36	−0.55	−0.24	−2.90	−1.71	−5.32	0.53	−1.81
DA:Food-Tobacco	−4.43	0.30	−1.64	−0.26	−3.08	−3.78	−0.31	−1.35	−1.82
DH:Plastics	−3.38	−1.46	1.27	−1.08	−6.21	−2.04	−1.55	−2.00	−2.06
DD:Wood	−5.63	−3.43	3.17	−0.41	−4.99	−4.36	−2.68	−2.34	−2.58
DG:Chemicals	−8.58	−2.60	7.20	−7.38	−5.40	−2.28	−7.24	0.52	−3.22

Source: Own computation based on Supply-Use Tables (SUT) and National Accounts Data, ISTAT

On average, with the exception of the first 6 sectors, hyper-integrated labour productivity changes exceeds TFP Growth. Interestingly though, exceptions are not unrelated: *KK:Business Services*, *OO:Personal Services* and *PP:Household Services* represent the core of private service subsystems, *EE:Energy* and *DF:Coke-Petroleum* are the two most important energy sectors and, finally, *FF:Construction* is quite special given that when shifting from industry to growing subsystem its net product almost vanishes. Moreover, this pattern of differences is not uniform across years, and it can be noticed that most sign changes agglomerate in particular combinations of sectors and years (e.g. 2001-2002, and *BB:Fishing*, *HH:Hotel-Restaurant*, *JJ:Finance*, *NN:Health* in 2003-2004).

The different unit of analysis (industry versus growing subsystem), the contrasting treatment of produced means of production (fixed capital, in particular), the dependence on a standard of value in the case of TFPG, the different consideration of imported commodities and, most fundamentally, the fact that hyper-integrated labour productivity departs from the expenditure system rather than from the system of revenue outlay relations (i.e. from a theory of value added), explain the sharp disagreement in the results obtained.

Thus, rather than focusing on absolute differences in growth rates of isolated industries or individual subsystems, it would be desirable to compare the whole sectoral distribution behind aggregate growth *within* each alternative method, expecting to see differences in the complete sectoral pattern of productivity changes. In order to do so, we follow a methodology introduced by Harberger (1998) for the study of traditional TFP Growth, which consists in computing the absolute real cost reductions due to productivity increases.

The crucial point in Harberger's (1998) argument consists in recognising the *additive* nature of TFP improvements, once turned into monetary units at base-year prices. Hence, he computed the absolute value added of the initial year that can be saved by means of proportional increases in TFP.

In our case, instead of measuring real cost reductions in terms of initial value added, these will be measured in terms of industry's *gross output* valued at base year prices (for Input-Output TFP) and in terms of quantities of labour (for hyper-integrated labour productivity). Thus, under the second method real cost reductions translate into an absolute saving of labour requirements.

Therefore, for TFPG, if $G_{j(0)} = \tilde{\mathbf{p}}_{(0)}^T \mathbf{V}_q \mathbf{e}_j$ represents current gross output of industry j valued at base year ($t = 0$) Input-Output prices$\tilde{\mathbf{p}}_{(0)}^T$, then, the real cost reduction due to TFP increases is given by:

$$CS_{tfp,j} = G_{j(0)} \left(1 - e^{-\rho_{tfp,j}}\right), \qquad j = 1, \dots, n \tag{3.6}$$

In contradistinction, if $L_\eta^{(i)}$ represents the total labour of growing subsystem i and $\alpha_\eta^{(i)}$ is the corresponding level of hyper-integrated labour productivity, then the absolute saving of labour requirements due to productivity increases is given by:

$$LS_\eta^{(i)} = L_\eta^{(i)} \left(1 - e^{-d \ln \alpha_\eta^{(i)}}\right), \qquad i = 1, \dots, n \tag{3.7}$$

Tables 13 and 14 display real cost reductions (in millions of monetary units at base-year prices per year) and absolute saving of labour requirements (in thousand of employment units per year) for Italy (1999-2007) due to increases in TFP and hyper-integrated productivity growth, respectively.

Table 13: Absolute real cost reduction at the industry level, Italy - $CS_{tfp,j}$ (mln.MU base-year pr. per year)

act	99-00	00-01	01-02	02-03	03-04	04-05	05-06	06-07	mean
II:Transport-Comm.	4267.52	3438.46	2199.64	−363.28	−161.94	1999.90	−1402.65	315.18	1286.60
JJ:Finance	1989.36	−222.05	−1508.45	−245.59	1086.07	1645.92	1641.70	3376.29	970.41
LL:Public Admin.	−128.00	915.10	594.93	1180.45	1065.65	739.40	−661.49	−46.04	457.50
DK:Machinery n.e.c.	1586.53	−387.69	−1069.48	−61.68	1207.57	81.81	1336.97	816.95	438.87
NN:Health	225.93	598.66	−217.69	−314.15	673.72	1066.47	621.01	175.89	353.73
DJ:Metals	725.40	377.75	−6.93	−1.10	−533.00	254.28	881.10	579.55	284.63
DA:Food-Tobacco	2122.65	−1128.69	110.68	−511.12	−511.24	1013.92	495.62	519.88	263.96
DL:Electr. Machinery	884.74	299.89	−834.47	−841.16	851.96	172.79	423.19	464.09	177.63
DC:Leather	421.22	253.39	−476.77	−295.34	−27.71	191.43	275.32	41.05	47.82
DD:Wood	345.74	285.30	−484.35	−137.21	88.53	−140.57	134.93	196.10	36.06
MM:Education	−230.71	−165.81	838.32	213.06	343.37	−755.00	−259.10	287.51	33.96
DM:Transport Equip.	534.37	−596.97	−508.57	−321.94	−8.16	−515.94	1005.26	613.91	25.25
PP:Household Services	24.04	68.08	−0.83	−6.17	25.06	25.24	27.34	35.22	24.75
DN:Manufacture n.e.c.	565.42	−508.88	−187.49	−501.19	100.76	216.34	386.11	44.40	14.43
DG:Chemicals	−418.23	−375.96	240.22	−356.85	530.66	−127.42	453.39	89.04	4.36
DI:Non-met. minerals	358.97	−1.91	219.88	−547.27	78.52	−7.41	66.79	−153.82	1.72
CB:Mining non-energy	−45.05	138.37	−14.51	−107.99	−118.02	151.01	−18.60	−73.08	−10.98
DB:Textiles	1513.41	−73.35	−861.88	−1255.37	−40.62	83.98	557.81	−109.16	−23.15
AA:Agriculture	−1383.84	−1159.55	−267.18	−866.32	4689.94	−992.81	−1171.96	871.57	−35.02
BB:Fishing	243.46	−287.22	−80.32	88.50	−150.02	−122.89	61.31	−38.38	−35.70
DH:Plastics	−210.87	−264.06	530.83	−506.96	281.19	−233.94	118.91	−97.83	−47.84
DE:Paper-Printing	137.91	−80.26	−445.91	−506.32	226.45	−59.92	114.08	81.70	−66.53
FF:Construction	803.83	229.29	−247.99	4.33	62.81	−754.04	269.83	−1173.65	−100.70
EE:Energy	−1363.55	561.29	365.34	−174.41	−156.85	−159.00	143.44	−261.22	−130.62
DF:Coke-Petroleum	−328.75	33.86	254.95	−396.92	−464.85	−298.30	−225.52	129.45	−162.01
HH:Hotel-Restaurant	834.21	−845.75	−3081.69	−1828.25	−579.88	214.46	978.08	672.89	−454.49
GG:Trade	2138.50	−161.44	−5317.50	−4232.42	1478.84	789.47	−540.03	519.93	−665.58
KK:Business Services	3061.18	1660.20	3033.09	−202.18	−4529.34	−4531.95	−75.91	−4436.47	−752.67
OO:Personal Services	−1770.98	−1352.15	−1612.61	−1514.42	1534.34	−1750.00	−395.35	67.50	−849.21

Source: Own computation based on Supply-Use Tables (SUT) and National Accounts Data, ISTAT

Table 14: Absolute labour saving in the growing subsystem, Italy - $LS_{\eta}^{(i)}$ (th.ULE per year)

act	99-00	00-01	01-02	02-03	03-04	04-05	05-06	06-07	mean
LL:Public Admin.	16.67	12.74	11.20	27.69	51.34	64.71	31.73	35.66	31.47
DA:Food-Tobacco	91.17	−19.08	23.69	−3.27	35.49	64.54	10.53	24.78	28.48
II:Transport-Comm.	60.75	31.22	31.75	−7.78	8.82	23.23	−3.69	7.81	19.01
DK:Machinery n.e.c.	55.32	9.23	−38.32	3.24	53.00	12.68	37.08	9.89	17.76
DB:Textiles	64.12	−4.43	−6.20	−14.58	26.58	16.35	50.99	−5.60	15.90
NN:Health	20.72	23.63	3.81	−10.68	10.61	22.94	27.56	19.86	14.81
DG:Chemicals	25.39	6.38	−25.05	25.98	22.30	6.77	26.51	−1.17	10.89
MM:Education	−14.17	33.73	25.60	18.95	7.66	−9.47	−9.35	7.26	7.53
DL:Electr. Machinery	23.69	−1.70	−4.33	−8.55	20.28	15.47	9.00	2.72	7.07
DM:Transport Equip.	35.36	0.50	0.10	0.68	−7.44	−4.04	8.33	20.09	6.70
JJ:Finance	16.67	6.94	−15.81	2.10	1.23	9.82	5.70	22.77	6.18
DN:Manufacture n.e.c.	37.90	−4.27	−13.49	−8.30	20.12	−0.70	13.75	3.93	6.12
DC:Leather	37.80	4.96	−20.46	−6.58	16.25	5.67	14.41	−3.71	6.04
GG:Trade	51.81	−52.77	−100.17	−48.99	63.71	99.85	−12.20	33.71	4.37
AA:Agriculture	−9.03	−7.02	−3.27	5.34	22.87	15.88	−8.64	12.77	3.61
DH:Plastics	4.15	0.94	0.89	−0.81	11.39	2.13	3.05	2.67	3.05
DJ:Metals	14.64	4.78	−6.71	2.28	15.52	1.55	−3.09	−4.92	3.01
DE:Paper-Printing	4.18	5.34	−0.20	−2.13	8.45	2.92	1.93	2.50	2.87
DI:Non-met. minerals	9.84	−3.56	−3.56	−3.02	4.49	6.36	5.08	−2.77	1.61
DD:Wood	3.62	2.42	−2.92	−0.16	2.42	1.58	1.35	1.28	1.20
CB:Mining non-energy	0.35	0.63	−0.44	−0.13	−0.48	0.16	0.45	−0.28	0.03
PP:Household Services	0.64	2.03	−0.47	−0.21	−0.82	−0.48	−0.26	−0.18	0.03
FF:Construction	2.92	0.02	−1.62	−0.62	1.94	−2.04	1.19	−2.42	−0.08
BB:Fishing	6.07	−6.46	−2.25	3.25	−3.54	−2.06	1.23	−1.17	−0.62
EE:Energy	−3.84	−7.34	−2.21	−10.03	21.87	5.42	−0.12	−10.87	−0.89
DF:Coke-Petroleum	−2.29	7.58	−2.45	−14.49	−26.52	−9.32	−10.17	13.76	−5.49
HH:Hotel-Restaurant	38.63	−16.61	−97.98	−84.40	−19.18	33.88	36.53	46.89	−7.78
OO:Personal Services	−27.95	−44.21	−33.57	−21.31	70.34	−35.11	−13.90	3.56	−12.77
KK:Business Services	−19.44	−46.00	−26.15	2.02	−44.21	−68.12	−6.05	−40.90	−31.11

Source: Own computation based on Supply-Use Tables (SUT) and National Accounts Data, ISTAT

A positive figure in Table 13 means a reduction in real costs, while in Table 14 indicates a saving of labour requirements induced by productivity increases. Given that total employment has increased, labour saving trends have been offset by the dynamics of final effective demand by commodity.

It is noticeable that by looking at the top nine and bottom eight industries/subsystems in each Table, there is great similarity as to the sectors with highest and lowest real cost reductions and absolute labour saving trends.

Among the common industries/subsystems with highest absolute cost improvements/productivity increases we find *II:Transport-Comm.*, *NN:Health*, *LL:Public Admin.* among services, and *DA:Food-Tobacco*, *DK:Machinery n.e.c.*, *DL:Electr. Machinery* among manufacturing. As to the sectors with worst performance we find the energy complex (*CA:Mining energy*, *DF:Coke-Petroleum*, *EE:Energy*) and a core of private services (*KK:Business Services*, *OO:Personal Services*, *HH:Hotel-Restaurant*).

A more subtle point is related to the volatility of real cost reductions across industries. If, on the basis of Table 13, we compute the coefficient of variation (cv)[20] across years for each industry, we find that those activities with highest (on average) cost reductions have the lowest volatility (as measured by the cv). This suggests that cost-reducing industries have been more persistent in their performance during the whole 1999-2007 period. A similar point can be made for absolute labour saving across growing subsystems, though to a lesser extent, as there is less dispersion between sectors in the coefficients of variation across time periods.

This last observation suggests that it would be interesting to study the degree of concentration of sectoral productivity increases.

To that end, Harberger (1998) introduced a particular Lorenz-curve type of diagram (a Harberger diagram, hereinafter), that displays the cumulated absolute contribution to aggregate growth of each sector (on the y-axis), according to its cumulated share of the initial level variable (on the x-axis). By rescaling the y-axis in such a way that the y-value corresponding to the x-value of 100% equals the aggregate growth rate, and ordering sectors (in a decreasing order) according to their growth *rate*, a concave diagram obtains, displaying the disaggregated pattern of absolute contributions to overall absolute labour saving or real cost reduction.

Harberger diagrams of average trends for both hyper-integrated labour productivity changes and Input-Output TFP Growth are built using the information of Tables 14 and 13, respectively, together with data on productivity growth rates. Figure 2 displays the respective diagrams for both hyper-integrated labour productivity changes (VHILPC) and Input-Output

[20] The coefficient of variation is the ratio between the standard deviation and the mean.

TFP Growth (TFPG).

Complementarily, in order to characterise the pervasiveness and curvature of each diagram in Figure 2, two summary statistics due to Inklaar & Timmer (2007, p. 178) are reported in Table 15.[21]

Table 15: Yeast vs. Mushrooms Patterns, Italy, (average 1999-2007)

Concept	ρ	Pervasiveness	Curvature
VHILPC (ρ^*)	0.62	77.84	0.53
TFPG (ρ_{tfp})	0.11	54.88	0.85

Source: Own computation based on Supply-Use Tables (SUT) and National Accounts Data, ISTAT

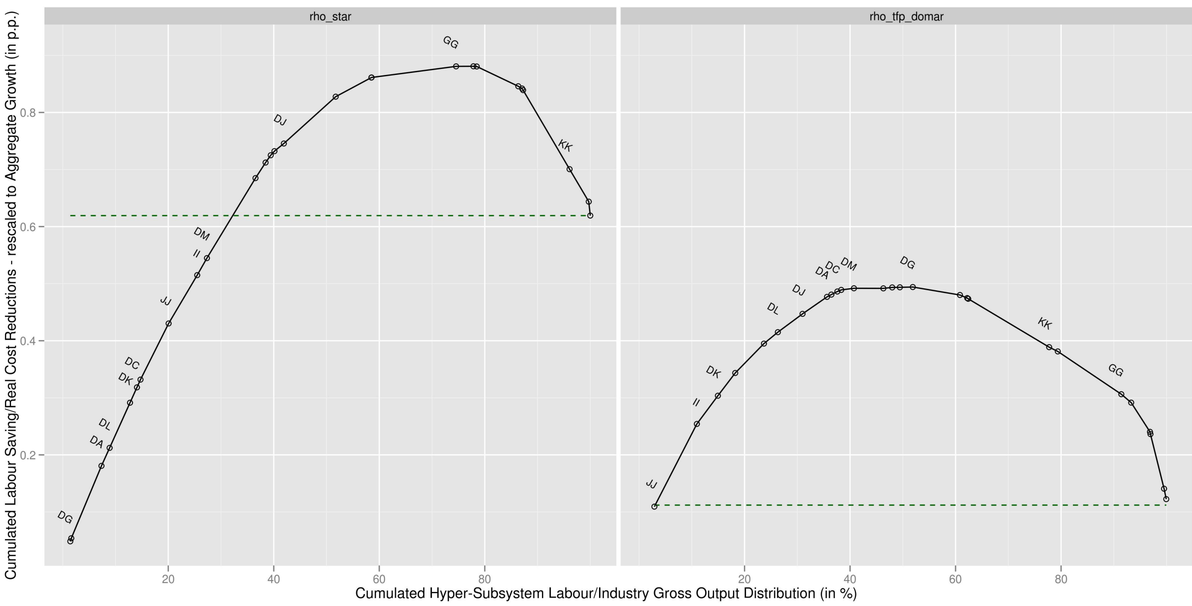

Figure 2: Harberger diagrams of Italy for ρ^* and ρ_{tfp}, 1999-2007

It clearly emerges that the pattern depicted by hyper-integrated productivity growth shows a more diffused and balanced character than that of TFP Growth. The fact that all industries participate in each growing subsystem (though in different proportions) provides a first intuition for this result. However, the contrast is due not only to a change in the unit of analysis, but

[21]Pervasiveness is measured by the cumulative share of sectors with positive contributions, while the curvature is measured by the ratio A/B, where A is the area between the curve and a straight line connecting the origin with the y-value corresponding to the aggregate growth rate (ρ), and B is the area below the curve. In this way the resulting statistic is contained between zero and one.

also to the fact that while hyper-integrated productivity growth is a physical measure of labour saving trends, TFPG is defined with reference to a system of relative prices and captures surplus/deficit conditions in value added per unit of gross output.

Not only ρ^* is much higher than ρ_{tfp}, but also the pervasiveness of hyper-integrated labour productivity is higher than that of TFP Growth, i.e. the cumulative share of sectors increasing labour productivity in total employment is almost 78%, while the cumulative share of industries increasing TFP in gross output at constant prices is only around 55%.

The higher curvature of TFPG suggests a clearly 'mushroom' like pattern, where few industries account for the greatest part of overall TFP Growth, while in the VHILPC case the pattern is more 'yeast' like. This last feature can be better illustrated by referring to the two diagrams in Figure 2. The dashed line splits the curve into two parts. To the left we can see those sectors/industries whose positive contribution to productivity changes is not counterbalanced by the negative contributions. In other words, these activities alone could account for the whole aggregate productivity growth. On the x-axis, in correspondence to the intersection with the dashed line, we can read the importance of such activities — in terms of the cumulated share in either total labour or gross output. In the VHILPC case, there are many sectors appearing to the left of the intersection, thus contributing to the productivity performance of the whole system, and accounting for more than 30% of total employment. On the contrary, in the TFPG case, one industry only — accounting for less than 6% of total gross output — appears to the left of the intersection (*JJ:Finance*).

4 Summary of findings and concluding remarks

The aim of the present paper has been that of formulating in input-output terms Pasinetti's (1959) ideas on the measurement of productivity growth (and the evaluation of technical change), making their vertically hyper-integrated nature explicit.

More efficient computation techniques, data availability allowing for a true separation between price and volume *growth* (by means of series of square commodity × activity Supply-Use Tables at current and past-year-prices), and the theoretical refinements that Pasinetti himself put forward after his Doctoral Thesis, have allowed us to compute his original 1959 measure, give empirical content to his 1981 'standard rate of growth of productivity', as well as to a set of sectoral measures of capital intensity and vertically (hyper-) integrated labour productivity changes.

The analytical operation of vertical hyper-integration aims at separating that part of gross output which re-enters the circular flow, i.e. replacements *and* new investments of both circulating and fixed capital inputs, from that which does not. Shifting the unit of analysis from industries *or* vertically integrated (VI) sectors *to* vertically hyper-integrated (VHI) sectors has allowed us to reach novel results from both a methodological and an empirical point of view.

An example of such a shift of perspective is represented by the analysis of VHI employment dynamics, which allows to consistently separate the effects of changes in the composition of final consumption demand from those of technical change (for details see section 3.2, page 32, and Table 6).

Vertical hyper-integration sheds light on the effects of growth on the network of inter-industry relations, and unfolds truly comprehensive backward linkages in a way which is unattainable not only within industry-level analysis, but also by means of traditional subsystems.

As to the identification of backward linkages, we computed the labour absorption exerted by each growing subsystem from its supporting industries (see column (4) of Table 4). Such a measure allows to quantify employment creation that might be stimulated by increases in final demand for different consumption commodities.[22] Interestingly, we found *LL:Public Administration* among one of the most important sectors as to hyper-integrated labour absorption.[23]

Another outcome of this shift of perspective concerns the quantification of activities' relative importance in terms of their share in total employment: activities mainly providing fixed capital inputs see their relative importance sharply reduced when considered as growing subsystems. An example, in the case analysed by the present paper, is represented by the subsystem *FF:Construction* (see section 3.2, page 29).

As to the interpretation of the empirical results, the multidimensional character of the effects of technical change prevents us from finding a unique scalar synthetic indicator that captures them all. For this reason, different typologies have been put forward to study the joint dynamics of the various measures computed.

A first typology was built according to the joint dynamics of VHI employment and labour productivity. In fact, labour saving trends induced by

[22]Note that final demand for consumption commodities includes private consumption as well as public consumption and exports.

[23]This important role of public expenditure in income generation is amplified if we consider that hyper-integrated backward linkages translate into a wider tax base (and therefore, tax revenues), allowing for further public stimulus to final demand, generating further income and so on, in a virtuous expenditure-income circle.

productivity increases and technological unemployment are two sides of the same coin. Thus, when *both* magnitudes are increasing a subsystem can really be defined as 'virtuous'.

Another typology was built according to the sectoral level of capital intensity and labour productivity changes relative to their respective aggregate values. This classification allowed us to identify, among the most dynamic subsystems, complexes of importance for the Italian economy like transport equipment and food products.

The patterns emerging from these two typologies suggest that the link between capital intensity and technological unemployment is subtle and should be treated with care.[24] In the first place, the ratio of fixed capital to labour should not be considered as an index of capital intensity but as indicator of the degree of mechanisation of the system. Secondly, the substitution of capital for labour is not the consequence of changing relative 'factor' prices triggering movements along an isoquant, but is instead a dynamic process intimately connected to the hyper-integrated productivity growth of subsystems producing machinery with respect to the standard rate of productivity growth and the dynamics of the real wage rate. In fact, the increasing degree of mechanisation in Italy is confirmed by the finding that in the machinery complex productivity grows much more than both ρ^* and the average real wage rate.

Finally, we compared the outcomes of our approach to that of traditional TFP Growth measurement. As detailed in section 3.4, changing the unit of analysis and recognising the purely physical-technical nature of productivity leads to completely different results and conclusions.

Further lines of research open up for exploration. Our very empirical analysis had to be restricted to a small set of results, but the computations performed would have allowed us to go deeper into many aspects.

Availability of more disaggregated data covering a longer period of time would have allowed us to draw more detailed conclusions on structural change and long-term trends of technical progress.[25]

Another interesting field of investigation is the juxtaposition of vertical hyper-integration and 'horizontal', as we might call it, clustering of industries. This might unfold key properties of convoluted multi-regional struc-

[24]This is clearly not the case in marginalist analyses of technical change, where the substitution mechanism conceives capital as an homogeneous quantity with a 'factor price' (the rate of profits), and suggests an inverse monotonic relation between the capital labour ratio and relative 'factor' prices (the ratio of the rate of profits to the real wage rate).

[25]An example is provided by the analysis of changes in capital intensities, which on such a short period of time (almost a decade) might simply reflect cyclical movements and the presence of idle productive capacity.

tures, where linkages might spread on a territorial dimension. This approach seems particularly promising for the analysis of the Italian productive system, whose core is represented by regional industrial districts.

Appendices

A Detailed Tables for Industries and (Growing) Subsystems

Table 16: Industry Labour distribution, Italy - L_j/L (%)

act	1999	2000	2001	2002	2003	2004	2005	2006	2007	mean
GG:Trade	14.69	14.59	14.57	14.49	14.56	14.45	14.31	14.38	14.26	14.48
KK:Business Services	9.39	9.91	10.21	10.72	10.97	11.13	11.26	11.37	11.60	10.73
FF:Construction	6.78	6.88	7.18	7.24	7.39	7.48	7.78	7.75	7.91	7.38
MM:Education	6.71	6.61	6.60	6.57	6.60	6.48	6.45	6.43	6.40	6.54
II:Transport-Comm.	6.51	6.51	6.47	6.48	6.49	6.45	6.55	6.60	6.64	6.52
NN:Health	6.04	6.09	6.09	6.07	6.11	6.17	6.19	6.10	6.05	6.10
LL:Public Admin.	6.30	6.22	6.09	5.98	5.78	5.73	5.64	5.52	5.41	5.85
HH:Hotel-Restaurant	5.19	5.51	5.53	5.63	5.81	5.92	5.93	5.85	5.83	5.69
AA:Agriculture	6.29	6.12	6.07	5.80	5.50	5.46	5.28	5.26	5.04	5.65
OO:Personal Services	3.95	3.97	4.04	4.02	4.01	4.07	4.09	4.24	4.25	4.07
DJ:Metals	3.56	3.44	3.44	3.44	3.54	3.46	3.48	3.61	3.67	3.52
PP:Household Services	3.11	3.10	3.18	3.20	3.17	3.30	3.42	3.48	3.59	3.28
DK:Machinery n.e.c.	2.47	2.47	2.44	2.44	2.49	2.51	2.55	2.59	2.57	2.50
JJ:Finance	2.56	2.51	2.51	2.47	2.44	2.45	2.45	2.47	2.52	2.49
DB:Textiles	2.77	2.70	2.66	2.61	2.58	2.45	2.30	2.13	2.09	2.48
DA:Food-Tobacco	2.04	1.98	1.87	1.88	1.89	1.94	1.89	1.89	1.90	1.92
DL:Electr. Machinery	1.91	1.90	1.85	1.85	1.86	1.84	1.88	1.90	1.91	1.88
DN:Manufacture n.e.c.	1.40	1.37	1.33	1.32	1.30	1.29	1.30	1.26	1.24	1.31
DM:Transport Equip.	1.26	1.22	1.14	1.10	1.00	1.07	1.06	1.08	1.12	1.12
DE:Paper-Printing	1.19	1.14	1.12	1.11	1.10	1.09	1.08	1.07	1.04	1.11
DI:Non-met. minerals	1.08	1.08	1.09	1.09	1.07	1.03	1.04	1.00	1.03	1.06
DG:Chemicals	0.93	0.90	0.87	0.88	0.85	0.83	0.84	0.83	0.82	0.86
DH:Plastics	0.93	0.92	0.90	0.90	0.88	0.85	0.82	0.78	0.77	0.86
DC:Leather	0.93	0.90	0.87	0.84	0.83	0.77	0.70	0.67	0.68	0.80
DD:Wood	0.81	0.80	0.78	0.79	0.76	0.74	0.69	0.68	0.66	0.75
EE:Energy	0.63	0.61	0.58	0.57	0.54	0.53	0.53	0.54	0.52	0.56
BB:Fishing	0.26	0.25	0.24	0.24	0.22	0.23	0.23	0.23	0.23	0.24
CB:Mining non-energy	0.15	0.14	0.14	0.14	0.13	0.13	0.13	0.12	0.12	0.14
DF:Coke-Petroleum	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.11	0.11
CA:Mining energy	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.03

Source: Own computation based on Supply-Use Tables (SUT) and National Accounts Data, ISTAT

Table 17: VI Labour distribution, Italy - $L_{\nu}^{(i)}/L$ (%)

act	2000	2001	2002	2003	2004	2005	2006	mean
GG:Trade	15.67	15.14	15.17	15.58	15.48	15.28	15.55	15.41
FF:Construction	7.51	8.07	8.01	8.17	8.17	7.88	7.99	7.97
LL:Public Admin.	7.90	7.76	7.75	7.62	7.62	7.70	7.47	7.69
NN:Health	7.27	7.17	7.26	7.41	7.54	7.74	7.76	7.45
HH:Hotel-Restaurant	6.86	7.30	7.04	7.32	7.38	7.41	7.67	7.28
KK:Business Services	6.66	6.53	7.13	7.00	6.66	6.86	7.44	6.90
MM:Education	6.65	6.77	6.57	6.60	6.47	6.41	6.46	6.56
DA:Food-Tobacco	5.70	5.40	5.20	5.46	5.10	5.05	5.55	5.35
II:Transport-Comm.	5.14	5.06	4.91	4.70	4.74	5.13	4.87	4.94
DK:Machinery n.e.c.	4.21	4.09	4.18	4.16	4.19	4.11	4.33	4.18
DB:Textiles	3.86	3.74	3.94	3.76	3.57	3.39	3.10	3.62
OO:Personal Services	2.95	3.13	3.20	3.34	3.55	3.22	3.52	3.27
PP:Household Services	3.10	3.18	3.20	3.17	3.30	3.42	3.48	3.26
DN:Manufacture n.e.c.	1.98	2.01	1.92	1.81	1.93	1.71	1.62	1.85
DL:Electr. Machinery	2.01	1.95	1.86	1.65	1.77	1.77	1.69	1.81
DM:Transport Equip.	2.02	1.84	1.85	1.80	1.65	1.69	1.71	1.79
DJ:Metals	1.58	1.88	1.76	1.77	1.59	1.77	2.08	1.78
JJ:Finance	1.52	1.52	1.43	1.42	1.42	1.51	1.71	1.51
AA:Agriculture	1.50	1.26	1.62	1.41	1.89	2.28	0.49	1.49
DG:Chemicals	1.16	1.20	1.44	1.41	1.42	1.27	1.19	1.30
DC:Leather	1.41	1.39	1.29	1.24	1.16	1.11	1.07	1.24
DE:Paper-Printing	0.88	0.98	0.79	0.90	0.93	0.87	0.83	0.88
DI:Non-met. minerals	0.76	0.81	0.72	0.58	0.64	0.62	0.54	0.67
DH:Plastics	0.57	0.58	0.71	0.55	0.59	0.56	0.59	0.59
EE:Energy	0.48	0.51	0.59	0.59	0.66	0.64	0.61	0.58
DF:Coke-Petroleum	0.20	0.21	0.20	0.18	0.18	0.21	0.27	0.21
DD:Wood	0.26	0.20	0.15	0.21	0.22	0.15	0.17	0.19
BB:Fishing	0.19	0.25	0.17	0.17	0.16	0.17	0.22	0.19
CB:Mining non-energy	0.03	0.04	0.05	0.01	0.02	0.05	0.03	0.03

Source: Own computation based on Supply-Use Tables (SUT) and National Accounts Data, ISTAT

Table 18: VHI Labour distribution, Italy - $L_{\eta}^{(i)}/L$ (%)

act	1999	2000	2001	2002	2003	2004	2005	2006	2007	mean
GG:Trade	16.35	16.15	15.95	15.99	16.10	16.04	15.74	16.05	15.89	16.03
LL:Public Admin.	9.53	9.42	9.39	9.40	9.36	9.29	9.07	8.79	8.57	9.20
KK:Business Services	7.91	8.16	8.43	8.64	8.69	8.98	9.41	9.45	9.62	8.81
NN:Health	7.61	7.64	7.64	7.75	7.90	8.10	8.27	8.16	8.10	7.91
HH:Hotel-Restaurant	7.25	7.58	7.66	7.81	8.03	8.20	8.11	8.17	8.07	7.87
MM:Education	7.05	6.98	6.85	6.77	6.77	6.62	6.67	6.61	6.58	6.76
DA:Food-Tobacco	6.20	5.85	5.75	5.74	5.72	5.71	5.66	5.51	5.36	5.72
II:Transport-Comm.	5.46	5.39	5.18	5.09	5.35	5.54	5.57	5.61	5.60	5.42
DK:Machinery n.e.c.	3.79	3.80	3.87	3.85	3.84	3.84	3.78	3.88	4.14	3.87
DB:Textiles	4.19	4.08	4.18	3.98	3.90	3.68	3.47	3.17	3.11	3.75
OO:Personal Services	3.22	3.43	3.63	3.73	3.80	3.56	3.73	3.83	3.80	3.64
PP:Household Services	3.11	3.10	3.18	3.20	3.17	3.30	3.42	3.48	3.59	3.28
AA:Agriculture	1.99	2.01	2.08	2.08	1.87	1.86	1.83	1.80	1.76	1.92
DN:Manufacture n.e.c.	2.19	2.11	2.05	2.02	1.92	1.85	1.78	1.69	1.63	1.92
DM:Transport Equip.	2.03	2.04	1.77	1.79	1.67	1.77	1.75	1.84	1.91	1.84
DJ:Metals	1.54	1.66	1.65	1.62	1.63	1.76	1.83	2.09	2.28	1.78
JJ:Finance	1.40	1.52	1.62	1.58	1.48	1.42	1.57	1.77	1.87	1.58
DL:Electr. Machinery	1.53	1.64	1.69	1.53	1.50	1.48	1.49	1.51	1.53	1.54
DG:Chemicals	1.47	1.45	1.50	1.65	1.49	1.37	1.40	1.29	1.27	1.43
DC:Leather	1.53	1.49	1.46	1.39	1.33	1.25	1.16	1.11	1.12	1.32
DE:Paper-Printing	1.05	1.02	1.00	0.98	1.00	0.95	0.96	0.93	0.92	0.98
EE:Energy	0.74	0.66	0.68	0.72	0.80	0.77	0.76	0.72	0.72	0.73
DI:Non-met. minerals	0.76	0.76	0.76	0.74	0.70	0.69	0.64	0.61	0.63	0.70
DH:Plastics	0.68	0.70	0.69	0.69	0.68	0.66	0.65	0.65	0.64	0.67
FF:Construction	0.70	0.68	0.68	0.65	0.64	0.59	0.56	0.57	0.57	0.63
DF:Coke-Petroleum	0.29	0.26	0.24	0.23	0.27	0.33	0.33	0.33	0.31	0.29
BB:Fishing	0.21	0.20	0.18	0.19	0.17	0.18	0.18	0.19	0.18	0.19
DD:Wood	0.22	0.21	0.21	0.20	0.19	0.18	0.16	0.15	0.14	0.19
CB:Mining non-energy	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
CA:Mining energy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00

Source: Own computation based on Supply-Use Tables (SUT) and National Accounts Data, ISTAT

Table 19: Labour redistribution between Industry and Growing Subsystem, Italy - $L_{\eta}^{(i)}/L - L_j/L$ (pp)

act	1999	2000	2001	2002	2003	2004	2005	2006	2007	mean
DA:Food-Tobacco	4.16	3.87	3.88	3.86	3.83	3.77	3.78	3.62	3.46	3.80
LL:Public Admin.	3.22	3.20	3.31	3.42	3.58	3.56	3.44	3.27	3.17	3.35
HH:Hotel-Restaurant	2.06	2.07	2.13	2.18	2.22	2.27	2.18	2.31	2.25	2.19
NN:Health	1.57	1.54	1.55	1.68	1.79	1.93	2.07	2.06	2.05	1.80
GG:Trade	1.65	1.55	1.38	1.50	1.54	1.58	1.43	1.67	1.63	1.55
DK:Machinery n.e.c.	1.32	1.33	1.43	1.42	1.36	1.33	1.23	1.30	1.57	1.36
DB:Textiles	1.42	1.38	1.52	1.36	1.33	1.23	1.17	1.04	1.02	1.27
DM:Transport Equip.	0.77	0.83	0.62	0.69	0.67	0.71	0.68	0.75	0.80	0.72
DN:Manufacture n.e.c.	0.79	0.74	0.72	0.69	0.63	0.56	0.48	0.43	0.40	0.60
DG:Chemicals	0.54	0.55	0.63	0.77	0.64	0.54	0.56	0.46	0.45	0.57
DC:Leather	0.59	0.58	0.60	0.55	0.50	0.49	0.46	0.44	0.44	0.52
MM:Education	0.34	0.37	0.24	0.20	0.17	0.14	0.23	0.18	0.18	0.23
DF:Coke-Petroleum	0.17	0.15	0.13	0.13	0.17	0.22	0.23	0.23	0.21	0.18
EE:Energy	0.10	0.05	0.10	0.15	0.25	0.24	0.23	0.18	0.21	0.17
PP:Household Services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CA:Mining energy	−0.03	−0.03	−0.03	−0.04	−0.04	−0.04	−0.04	−0.04	−0.01	−0.03
BB:Fishing	−0.06	−0.05	−0.06	−0.05	−0.05	−0.05	−0.04	−0.05	−0.05	−0.05
CB:Mining non-energy	−0.12	−0.11	−0.11	−0.11	−0.11	−0.10	−0.10	−0.09	−0.09	−0.10
DE:Paper-Printing	−0.14	−0.13	−0.12	−0.14	−0.10	−0.14	−0.11	−0.14	−0.13	−0.13
DH:Plastics	−0.25	−0.23	−0.21	−0.21	−0.19	−0.18	−0.16	−0.13	−0.13	−0.19
DL:Electr. Machinery	−0.38	−0.27	−0.16	−0.32	−0.36	−0.36	−0.39	−0.39	−0.38	−0.33
DI:Non-met. minerals	−0.32	−0.32	−0.33	−0.35	−0.36	−0.34	−0.41	−0.39	−0.39	−0.36
OO:Personal Services	−0.73	−0.54	−0.40	−0.29	−0.21	−0.50	−0.36	−0.42	−0.46	−0.44
DD:Wood	−0.59	−0.58	−0.57	−0.58	−0.58	−0.56	−0.53	−0.53	−0.51	−0.56
JJ:Finance	−1.16	−0.99	−0.89	−0.89	−0.97	−1.03	−0.88	−0.70	−0.66	−0.91
II:Transport-Comm.	−1.05	−1.12	−1.29	−1.39	−1.14	−0.91	−0.98	−0.98	−1.03	−1.10
DJ:Metals	−2.02	−1.78	−1.79	−1.82	−1.91	−1.71	−1.65	−1.51	−1.38	−1.73
KK:Business Services	−1.48	−1.75	−1.78	−2.08	−2.28	−2.15	−1.85	−1.92	−1.98	−1.92
AA:Agriculture	−4.30	−4.11	−3.99	−3.72	−3.63	−3.61	−3.45	−3.46	−3.28	−3.73
FF:Construction	−6.08	−6.20	−6.50	−6.59	−6.75	−6.89	−7.21	−7.18	−7.34	−6.75

Source: Own computation based on Supply-Use Tables (SUT) and National Accounts Data, ISTAT

Table 20: Industry Labour Growth and Commodity Gross Output Growth, Italy (in p.p.)

	99-00		00-01		01-02		02-03		03-04		04-05		05-06		06-07		mean	
	$\Delta\%L_j$	$\Delta\%q_i$	$\Delta\%L_j$	$\Delta\%q_i$	$\Delta\%L_j$	$\Delta\%q_i$	$\Delta\%L_j$	$\Delta\%q_i$	$\Delta\%L_j$	$\Delta\%q_i$	$\Delta\%L_j$	$\Delta\%q_i$	$\Delta\%L_j$	$\Delta\%q_i$	$\Delta\%L_j$	$\Delta\%q_i$	$\Delta\%L_j$	$\Delta\%q_i$
AA:Agriculture	−0.88	−1.86	0.96	−0.66	−3.40	−1.86	−4.67	−4.03	−0.28	9.47	−3.20	−2.76	1.05	−1.80	−3.18	0.11	−1.70	−0.42
BB:Fishing	−4.73	9.24	0.52	−9.53	−0.34	−5.36	−7.90	0.78	5.28	−2.98	−1.25	−6.59	3.70	5.87	1.20	−1.99	−0.44	−1.32
CA:Mining energy	−7.52	−9.71	−4.80	−13.50	44.30	17.80	−7.65	−4.92	1.13	−4.99	−2.27	3.16	2.27	−5.86	2.22	12.00	3.46	−0.75
CB:Mining non-energy	−2.34	−2.11	−0.30	2.67	2.64	6.71	−5.95	−4.94	−4.39	−3.40	2.53	9.79	−4.47	−3.69	−2.99	−8.26	−1.91	−0.40
DA:Food-Tobacco	−1.09	5.42	−4.07	−2.72	1.78	−0.73	1.38	2.08	2.91	1.37	−2.74	2.08	1.81	−0.23	1.31	1.85	0.16	1.14
DB:Textiles	−0.69	5.88	0.08	0.62	−0.49	−1.12	−0.83	−4.64	−4.53	−4.28	−6.21	−3.50	−5.98	−2.87	−1.06	−1.15	−2.47	−1.38
DC:Leather	−1.60	5.14	−2.06	4.68	−2.20	−6.34	−0.89	−4.48	−7.17	−5.75	−9.01	−3.23	−2.13	0.91	2.07	0.65	−2.87	−1.05
DD:Wood	0.43	4.84	−0.21	1.13	1.70	−4.76	−2.08	0.12	−2.45	1.35	−6.85	−6.33	0.24	−0.71	−2.87	5.77	−1.51	0.18
DE:Paper-Printing	−2.00	3.68	−0.34	4.07	0.71	−2.63	−0.22	1.69	−0.71	2.50	−1.32	0.52	1.02	1.45	−1.44	0.63	−0.54	1.49
DF:Coke-Petroleum	1.88	−0.51	−1.88	2.32	−9.57	−1.53	−0.42	0.93	3.71	0.76	3.19	−1.49	1.56	−2.43	1.53	2.06	0.00	0.01
DG:Chemicals	−1.56	−2.63	−0.86	−1.29	2.38	7.50	−3.34	−3.06	−1.81	3.06	1.13	−1.62	1.07	−1.29	−0.73	0.98	−0.47	0.21
DH:Plastics	0.93	−0.44	−1.16	−1.70	1.25	8.74	−1.91	−3.82	−2.77	0.18	−3.65	−4.34	−3.01	0.81	−0.62	−0.59	−1.37	−0.15
DI:Non-met. minerals	1.28	5.40	2.85	7.85	0.96	4.07	−1.27	−3.02	−3.50	1.29	1.86	−1.04	−2.62	−1.54	3.37	2.04	0.37	1.88
DJ:Metals	−1.44	2.03	1.73	4.29	1.13	2.00	3.46	2.13	−1.71	−2.11	0.64	0.81	5.07	5.01	2.58	4.99	1.43	2.39
DK:Machinery n.e.c.	1.72	6.62	0.53	1.62	1.03	0.52	2.67	2.55	1.20	4.24	1.64	0.29	3.18	7.30	0.11	3.14	1.51	3.29
DL:Electr. Machinery	1.54	5.16	−1.13	5.06	1.29	−2.37	1.51	−2.60	−0.64	3.92	1.94	0.95	2.71	2.85	1.73	4.01	1.12	2.12
DM:Transport Equip.	−1.64	5.25	−4.31	−2.23	−2.53	−4.05	−8.88	−3.66	6.83	1.76	−0.23	−5.22	3.18	7.86	3.95	6.66	−0.45	0.80
DN:Manufacture n.e.c.	−0.62	4.97	−0.97	0.37	0.79	0.04	−1.23	−3.63	−0.03	2.45	0.60	−1.98	−1.56	0.60	−1.00	−1.53	−0.50	0.16
EE:Energy	−1.81	−0.41	−3.35	2.49	−1.02	3.23	−3.50	3.78	−2.69	3.23	0.93	2.29	2.51	1.41	−2.36	−0.11	−1.41	1.99
FF:Construction	3.24	3.78	6.02	5.12	2.07	3.01	2.71	1.43	1.63	1.17	4.02	2.15	1.20	1.19	2.96	1.02	2.98	2.36
GG:Trade	1.14	4.39	1.60	1.62	0.71	0.03	1.13	−0.54	−0.38	2.22	−0.84	0.73	2.04	3.07	0.08	1.89	0.68	1.68
HH:Hotel-Restaurant	7.75	8.94	2.13	2.35	3.09	−3.93	3.78	−0.40	2.30	0.46	0.21	0.72	0.30	2.93	0.47	1.76	2.50	1.60
II:Transport-Comm.	1.82	8.32	1.10	5.58	1.49	4.09	0.73	2.59	−0.21	1.21	1.68	3.63	2.23	0.47	1.60	3.41	1.31	3.66
JJ:Finance	−0.39	6.44	1.67	3.48	−0.05	−0.98	−0.71	0.17	0.82	3.77	0.18	5.16	2.29	5.97	3.02	4.82	0.86	3.60
KK:Business Services	7.17	5.73	4.79	3.26	6.13	4.00	2.91	2.10	1.82	−0.16	1.34	0.22	2.49	2.30	2.98	1.48	3.70	2.37
LL:Public Admin.	0.38	1.28	−0.36	2.15	−0.47	1.89	−2.78	1.85	−0.51	1.27	−1.48	1.05	−0.59	−0.18	−1.04	0.53	−0.86	1.23
MM:Education	0.42	0.50	1.58	1.73	0.76	2.30	1.09	1.38	−1.50	−0.65	−0.31	−1.57	1.27	−0.04	0.44	0.94	0.47	0.57
NN:Health	2.59	3.09	1.81	2.67	0.93	2.27	1.23	1.53	1.30	3.46	0.56	3.29	0.09	1.11	0.09	1.10	1.07	2.32
OO:Personal Services	2.32	−1.89	3.36	0.32	0.81	−1.01	0.29	−2.34	1.91	8.09	0.77	−4.86	5.15	2.01	1.19	0.73	1.97	0.13
PP:Household Services	1.68	1.77	4.11	4.39	1.89	1.82	−0.19	−0.22	4.32	4.22	3.74	3.68	3.39	3.36	3.98	3.95	2.86	2.87

Source: Own computation based on Supply-Use Tables (SUT) and National Accounts Data, ISTAT

Table 21: Commodity Net Output Growth and VI Labour Productivity Growth, Italy (in p.p.)

	00-01		01-02		02-03		03-04		04-05		05-06		mean	
	$\Delta\%y_i$	$\Delta\%\alpha_\nu^{(i)}$	$\Delta\%y_i$	$\Delta\%\alpha_\nu^{(i)}$	$\Delta\%y_i$	$\Delta\%\alpha_\nu^{(i)}$	$\Delta\%y_i$	$\Delta\%\alpha_\nu^{(i)}$	$\Delta\%y_i$	$\Delta\%\alpha_\nu^{(i)}$	$\Delta\%y_i$	$\Delta\%\alpha_\nu^{(i)}$	$\Delta\%y_i$	$\Delta\%\alpha_\nu^{(i)}$
AA:Agriculture	−25.24	−11.00	22.27	4.63	−14.95	−1.06	45.55	11.56	18.29	5.86	−165.67	−24.54	−19.96	−2.43
BB:Fishing	17.03	−16.14	−35.87	−0.27	8.64	5.48	−13.95	−7.17	11.26	−0.67	8.76	−14.75	−0.69	−5.59
CB:Mining non-energy	45.12	−0.45	20.33	4.01	−156.13	−11.79	60.22	−0.89	127.53	22.49	−118.20	−41.96	−3.52	−4.76
DA:Food-Tobacco	−12.59	−9.01	4.05	4.94	6.02	0.57	−0.34	6.53	6.36	5.66	−2.27	−15.39	0.21	−1.12
DB:Textiles	1.94	2.89	2.95	−3.70	−10.96	−6.58	−3.29	1.66	−1.23	3.78	−3.42	3.14	−2.33	0.20
DC:Leather	2.16	1.88	−11.40	−5.92	−9.31	−5.91	−5.53	2.85	0.13	4.48	1.35	4.71	−3.77	0.35
DD:Wood	−21.24	2.17	−34.82	−8.26	41.46	5.64	−3.17	−4.14	−39.78	1.98	25.63	7.04	−5.32	0.74
DE:Paper-Printing	6.35	−5.88	−23.88	−3.05	17.10	2.49	6.65	2.94	−10.05	−3.63	2.47	2.61	−0.23	−0.75
DF:Coke-Petroleum	−2.97	−18.34	−12.88	−5.13	12.68	16.99	−2.88	−10.83	0.51	−18.75	−11.98	−30.32	−2.92	−11.07
DG:Chemicals	14.49	9.38	18.54	−1.87	−9.46	−9.91	10.17	8.35	−10.94	−0.70	7.93	12.17	5.12	2.90
DH:Plastics	5.90	2.49	31.64	9.48	−31.77	−9.07	13.22	5.89	−11.63	−6.14	15.20	8.02	3.76	1.78
DI:Non-met. minerals	10.03	1.10	−5.26	3.34	−30.08	−10.16	11.60	2.49	−3.61	−0.12	−8.08	3.96	−4.23	0.10
DJ:Metals	20.49	1.18	−4.58	−0.51	−0.99	−3.72	−8.95	0.65	10.75	1.08	20.34	3.74	6.18	0.40
DK:Machinery n.e.c.	−2.12	−1.07	−0.65	−4.30	−0.59	−1.43	5.77	5.23	−2.38	−0.59	12.15	5.38	2.03	0.54
DL:Electr. Machinery	5.12	5.97	−10.87	−8.14	−15.54	−5.97	16.05	9.72	−0.69	0.60	−0.74	3.02	−1.11	0.86
DM:Transport Equip.	−17.52	−9.39	8.78	7.63	−9.23	−7.40	−4.07	5.37	−6.98	−9.35	12.60	9.92	−2.74	−0.53
DN:Manufacture n.e.c.	−5.87	−8.81	−0.19	2.64	−11.49	−6.91	8.25	2.74	−8.96	3.02	−0.38	2.51	−3.11	−0.80
EE:Energy	7.02	−2.49	4.12	−5.96	6.23	6.71	2.55	−8.75	3.00	5.51	0.28	−0.74	3.87	−0.95
FF:Construction	7.21	−1.51	1.69	0.79	−1.38	−4.16	1.07	0.62	−0.80	1.69	−1.67	−4.34	1.02	−1.15
GG:Trade	−1.06	−0.12	−2.70	−3.36	−2.39	−4.90	3.73	4.02	−1.10	−0.67	5.86	1.62	0.39	−0.57
HH:Hotel-Restaurant	0.06	−8.28	−5.68	−3.72	2.92	−1.90	0.37	−0.41	1.37	0.57	3.47	−0.21	0.42	−2.33
II:Transport-Comm.	0.38	0.61	−2.70	−0.62	−0.86	3.91	0.39	−0.55	9.82	2.09	−6.90	−3.31	0.02	0.36
JJ:Finance	−2.54	−0.36	−6.73	−2.82	−1.32	−2.89	7.22	5.13	3.90	1.92	9.83	2.82	1.73	0.63
KK:Business Services	−3.29	−2.51	5.39	−3.64	−4.04	−2.56	−6.09	−0.90	1.02	−2.82	8.18	−0.72	0.20	−2.19
LL:Public Admin.	2.31	2.31	1.87	0.59	1.90	2.66	1.28	1.36	0.97	−0.64	−0.18	1.31	1.36	1.26
MM:Education	1.26	−2.26	2.45	4.36	0.60	−0.45	−0.47	1.23	−2.55	−1.84	2.04	−0.13	0.56	0.15
NN:Health	2.43	2.12	2.65	−0.10	2.43	−0.20	4.12	1.69	3.45	0.82	0.93	−0.22	2.67	0.68
OO:Personal Services	5.99	−1.26	−2.15	−6.12	−1.76	−5.81	18.24	9.34	−20.07	−7.73	11.82	1.32	2.01	−1.71
PP:Household Services	4.39	0.28	1.82	−0.06	−0.22	−0.03	4.22	−0.11	3.68	−0.06	3.36	−0.03	2.88	0.00

Source: Own computation based on Supply-Use Tables (SUT) and National Accounts Data, ISTAT

Table 22: Commodity Final Consumption Growth and VHI Labour Productivity Growth, Italy (in p.p.)

	99-00		00-01		01-02		02-03		03-04		04-05		05-06		06-07		mean	
	$\Delta\%c_i$	$\Delta\%\alpha_\eta^{(i)}$	$\Delta\%c_i$	$\Delta\%\alpha_\eta^{(i)}$	$\Delta\%c_i$	$\Delta\%\alpha_\eta^{(i)}$	$\Delta\%c_i$	$\Delta\%\alpha_\eta^{(i)}$	$\Delta\%c_i$	$\Delta\%\alpha_\eta^{(i)}$	$\Delta\%c_i$	$\Delta\%\alpha_\eta^{(i)}$	$\Delta\%c_i$	$\Delta\%\alpha_\eta^{(i)}$	$\Delta\%c_i$	$\Delta\%\alpha_\eta^{(i)}$	$\Delta\%c_i$	$\Delta\%\alpha_\eta^{(i)}$
AA:Agriculture	2.52	−1.95	3.17	−1.48	−1.82	−0.66	−9.06	1.07	9.41	5.18	4.04	3.57	−2.26	−1.92	10.04	2.90	2.01	0.84
BB:Fishing	13.19	13.63	−20.43	−12.89	−1.58	−5.10	2.65	7.54	−1.01	−8.06	−3.30	−4.47	4.83	2.77	25.32	−2.52	2.46	−1.14
CB:Mining non-energy	11.64	4.96	−1.75	8.52	3.55	−6.15	−7.23	−1.73	8.86	−6.92	1.93	2.07	1.54	5.79	−1.92	−3.34	2.08	0.40
DA:Food-Tobacco	3.63	6.61	−1.04	−1.38	3.87	1.74	−0.05	−0.24	2.35	2.59	4.20	4.75	2.01	0.76	18.85	1.83	4.23	2.08
DB:Textiles	5.92	6.89	3.98	−0.46	−4.01	−0.62	−2.85	−1.51	−2.88	2.84	−4.02	1.84	−0.28	6.21	13.08	−0.71	1.12	1.81
DC:Leather	8.71	11.39	1.47	1.43	−9.54	−5.70	−5.98	−1.95	−1.41	5.18	−6.23	1.87	1.04	5.20	14.93	−1.34	0.37	2.01
DD:Wood	9.48	7.56	7.77	4.94	−7.26	−5.60	−7.60	−0.31	1.13	5.45	−8.13	3.63	2.18	3.44	6.67	3.42	0.53	2.82
DE:Paper-Printing	5.08	1.75	1.95	2.27	−1.49	−0.08	3.01	−0.90	−1.36	3.53	2.88	1.27	1.78	0.83	7.32	1.09	2.40	1.22
DF:Coke-Petroleum	−4.27	−3.40	5.77	13.10	−6.00	−4.24	6.64	−23.44	−6.04	−34.08	0.82	−11.12	−13.67	−11.73	5.91	18.37	−1.36	−7.07
DG:Chemicals	10.78	7.82	6.77	1.90	5.32	−6.76	−1.17	6.76	−0.81	6.36	4.57	2.05	2.70	8.08	7.43	−0.36	4.45	3.23
DH:Plastics	8.38	2.68	1.23	0.58	2.59	0.54	0.55	−0.49	5.59	7.11	−0.52	1.32	3.17	1.93	10.39	1.68	3.92	1.92
DI:Non-met. minerals	6.78	5.80	0.56	−1.99	−1.20	−1.94	−5.26	−1.68	0.64	2.66	−4.18	3.87	0.56	3.32	5.61	−1.81	0.44	1.03
DJ:Metals	12.73	4.22	2.51	1.24	−0.27	−1.69	3.37	0.58	12.42	4.00	2.96	0.36	12.71	−0.69	5.26	−0.94	6.46	0.89
DK:Machinery n.e.c.	8.11	6.56	4.40	1.04	−2.50	−4.07	1.67	0.35	5.33	5.85	−0.46	1.36	8.53	4.10	−2.25	1.03	2.85	2.03
DL:Electr. Machinery	12.84	6.99	4.86	−0.44	−8.49	−1.07	−1.31	−2.29	3.70	5.72	3.71	4.38	4.71	2.50	−4.43	0.73	1.95	2.07
DM:Transport Equip.	10.92	7.87	−13.12	0.10	2.09	0.02	−6.07	0.16	3.53	−1.82	−2.78	−0.93	8.80	1.97	17.69	4.51	2.63	1.49
DN:Manufacture n.e.c.	5.74	7.82	−2.29	−0.86	−2.26	−2.73	−5.31	−1.69	0.03	4.40	−4.32	−0.15	0.56	3.22	7.90	0.94	0.01	1.37
EE:Energy	−2.68	−2.24	1.52	−4.64	4.59	−1.36	4.22	−5.64	6.14	11.97	2.63	2.95	−3.60	−0.07	−5.20	−5.94	0.95	−0.62
FF:Construction	2.09	1.82	0.65	0.01	−3.34	−1.00	−1.03	−0.40	−4.20	1.26	−2.26	−1.40	2.74	0.87	0.22	−1.70	−0.64	−0.07
GG:Trade	2.92	1.39	−0.07	−1.39	−1.69	−2.60	−0.83	−1.26	1.48	1.64	1.54	2.59	4.25	−0.32	1.09	0.85	1.09	0.11
HH:Hotel-Restaurant	8.39	2.35	2.44	−0.93	−1.68	−5.23	−0.73	−4.38	1.05	−0.98	0.69	1.71	3.02	1.86	2.20	2.34	1.92	−0.41
II:Transport-Comm.	6.28	4.96	−0.33	2.50	1.71	2.60	3.87	−0.63	4.37	0.68	1.99	1.74	2.35	−0.27	4.92	0.56	3.15	1.52
JJ:Finance	5.14	5.31	6.45	1.97	−4.75	−4.01	−3.86	0.55	0.46	0.35	8.03	2.87	7.12	1.50	9.33	5.33	3.49	1.73
KK:Business Services	2.35	−1.06	2.09	−2.38	0.80	−1.29	0.91	0.10	0.96	−2.07	2.51	−3.06	0.72	−0.26	0.44	−1.73	1.35	−1.47
LL:Public Admin.	1.44	0.76	2.13	0.58	1.93	0.50	1.87	1.23	1.20	2.28	1.05	2.90	−0.21	1.44	0.52	1.65	1.24	1.42
MM:Education	−0.09	−0.87	1.83	2.08	1.60	1.58	1.76	1.17	−1.52	0.47	0.36	−0.59	−0.13	−0.57	0.77	0.44	0.57	0.46
NN:Health	2.87	1.19	3.09	1.33	3.24	0.21	2.06	−0.57	3.64	0.55	3.25	1.17	1.03	1.38	1.01	0.99	2.53	0.78
OO:Personal Services	2.42	−3.70	1.64	−5.35	0.41	−3.80	−0.41	−2.34	5.21	7.93	−1.55	−3.96	2.79	−1.51	1.30	0.38	1.48	−1.55
PP:Household Services	1.77	0.09	4.39	0.28	1.82	−0.06	−0.22	−0.03	4.22	−0.11	3.68	−0.06	3.36	−0.03	3.95	−0.02	2.87	0.01

Source: Own computation based on Supply-Use Tables (SUT) and National Accounts Data, ISTAT

Table 23: Units of VI Labour Growth, Italy - $\Delta\%L_{\nu}^{(i)}$ (pp)

act	00-01	01-02	02-03	03-04	04-05	05-06	mean
AA:Agriculture	−14.24	17.64	−13.89	33.98	12.43	−141.13	−17.53
BB:Fishing	33.18	−35.61	3.16	−6.78	11.93	23.52	4.90
CB:Mining non-energy	45.57	16.32	−144.34	61.11	105.04	−76.24	1.24
DA:Food-Tobacco	−3.58	−0.89	5.45	−6.87	0.70	13.12	1.32
DB:Textiles	−0.95	6.65	−4.38	−4.95	−5.01	−6.55	−2.53
DC:Leather	0.27	−5.48	−3.40	−8.38	−4.36	−3.36	−4.12
DD:Wood	−23.40	−26.56	35.82	0.97	−41.75	18.59	−6.06
DE:Paper-Printing	12.24	−20.83	14.60	3.71	−6.42	−0.15	0.53
DF:Coke-Petroleum	15.37	−7.75	−4.31	7.96	19.26	18.34	8.15
DG:Chemicals	5.11	20.41	0.44	1.82	−10.24	−4.24	2.22
DH:Plastics	3.41	22.16	−22.69	7.33	−5.48	7.19	1.99
DI:Non-met. minerals	8.93	−8.60	−19.93	9.11	−3.50	−12.04	−4.34
DJ:Metals	19.31	−4.07	2.73	−9.61	9.67	16.60	5.77
DK:Machinery n.e.c.	−1.05	3.65	0.83	0.54	−1.79	6.77	1.49
DL:Electr. Machinery	−0.85	−2.72	−9.57	6.33	−1.29	−3.76	−1.98
DM:Transport Equip.	−8.13	1.15	−1.83	−9.45	2.37	2.67	−2.20
DN:Manufacture n.e.c.	2.94	−2.83	−4.58	5.51	−11.98	−2.89	−2.31
EE:Energy	9.51	10.08	−0.49	11.30	−2.51	1.01	4.82
FF:Construction	8.72	0.90	2.78	0.45	−2.49	2.67	2.17
GG:Trade	−0.94	0.66	2.52	−0.30	−0.43	4.24	0.96
HH:Hotel-Restaurant	8.34	−1.96	4.82	0.78	0.80	3.68	2.74
II:Transport-Comm.	−0.23	−2.08	−4.77	0.94	7.73	−3.59	−0.33
JJ:Finance	−2.18	−3.92	1.57	2.09	1.98	7.01	1.09
KK:Business Services	−0.78	9.04	−1.48	−5.19	3.84	8.90	2.39
LL:Public Admin.	0.00	1.28	−0.76	−0.07	1.62	−1.48	0.10
MM:Education	3.51	−1.91	1.06	−1.70	−0.71	2.16	0.40
NN:Health	0.31	2.75	2.63	2.43	2.63	1.15	1.98
OO:Personal Services	7.24	3.97	4.05	8.90	−12.34	10.50	3.72
PP:Household Services	4.11	1.89	−0.19	4.32	3.74	3.39	2.88

Source: Own computation based on Supply-Use Tables (SUT) and National Accounts Data, ISTAT

Table 24: Units of VHI Labour Growth, Italy - $\Delta\% L_{\eta}^{(i)}$ (pp)

act	99-00	00-01	01-02	02-03	03-04	04-05	05-06	06-07	mean
AA:Agriculture	4.47	4.65	−1.16	−10.13	4.22	0.47	−0.34	7.14	1.17
BB:Fishing	−0.44	−7.54	3.52	−4.88	7.06	1.16	2.06	27.85	3.60
CB:Mining non-energy	6.68	−10.27	9.71	−5.50	15.78	−0.14	−4.25	1.41	1.68
DA:Food-Tobacco	−2.98	0.34	2.13	0.18	−0.23	−0.55	1.25	17.02	2.14
DB:Textiles	−0.97	4.44	−3.39	−1.35	−5.73	−5.86	−6.49	13.79	−0.69
DC:Leather	−2.68	0.03	−3.84	−4.03	−6.59	−8.10	−4.16	16.26	−1.64
DD:Wood	1.91	2.83	−1.66	−7.29	−4.33	−11.75	−1.26	3.25	−2.29
DE:Paper-Printing	3.33	−0.32	−1.40	3.91	−4.89	1.60	0.95	6.23	1.18
DF:Coke-Petroleum	−0.88	−7.32	−1.75	30.07	28.04	11.94	−1.93	−12.46	5.71
DG:Chemicals	2.97	4.86	12.07	−7.92	−7.17	2.52	−5.38	7.80	1.22
DH:Plastics	5.70	0.65	2.05	1.04	−1.51	−1.84	1.23	8.71	2.00
DI:Non-met. minerals	0.98	2.55	0.74	−3.58	−2.02	−8.04	−2.76	7.42	−0.59
DJ:Metals	8.51	1.27	1.42	2.78	8.42	2.60	13.40	6.20	5.58
DK:Machinery n.e.c.	1.55	3.36	1.57	1.32	−0.52	−1.82	4.43	−3.29	0.82
DL:Electr. Machinery	5.85	5.30	−7.42	0.97	−2.02	−0.67	2.21	−5.16	−0.12
DM:Transport Equip.	3.05	−13.22	2.07	−6.23	5.35	−1.85	6.83	13.18	1.15
DN:Manufacture n.e.c.	−2.08	−1.42	0.47	−3.62	−4.37	−4.17	−2.66	6.96	−1.36
EE:Energy	−0.44	6.16	5.95	9.86	−5.84	−0.32	−3.53	0.74	1.57
FF:Construction	0.27	0.64	−2.34	−0.63	−5.46	−0.86	1.87	1.93	−0.57
GG:Trade	1.53	1.31	0.91	0.43	−0.16	−1.05	4.57	0.24	0.97
HH:Hotel-Restaurant	6.04	3.38	3.55	3.65	2.03	−1.02	1.16	−0.14	2.33
II:Transport-Comm.	1.32	−2.83	−0.89	4.50	3.69	0.25	2.62	4.36	1.63
JJ:Finance	−0.17	4.48	−0.74	−4.42	0.12	5.16	5.62	3.99	1.76
KK:Business Services	3.42	4.47	2.09	0.81	3.03	5.57	0.98	2.17	2.82
LL:Public Admin.	0.68	1.56	1.43	0.64	−1.08	−1.85	−1.65	−1.13	−0.18
MM:Education	0.79	−0.26	0.01	0.60	−1.99	0.94	0.45	0.33	0.11
NN:Health	1.68	1.76	3.04	2.63	3.09	2.09	−0.35	0.03	1.74
OO:Personal Services	6.12	7.00	4.22	1.93	−2.73	2.41	4.30	0.92	3.02
PP:Household Services	1.68	4.11	1.89	−0.19	4.32	3.74	3.39	3.98	2.86

Source: Own computation based on Supply-Use Tables (SUT) and National Accounts Data, ISTAT

Table 25: Hyper-inetgrated labour productivity growth decomposition, Italy (1999-2007)

	99-00				**03-04**				**06-07**				**mean**			
	$\Delta\%\alpha_{\eta}^{(i)}$	$\Delta\%\alpha_{\eta,d}^{(i)}$	$\Delta\%\alpha_{\eta,hy}^{(i)}$	$\omega_{\eta,d}^{(i)}$	$\Delta\%\alpha_{\eta}^{(i)}$	$\Delta\%\alpha_{\eta,d}^{(i)}$	$\Delta\%\alpha_{\eta,hy}^{(i)}$	$\omega_{\eta,d}^{(i)}$	$\Delta\%\alpha_{\eta}^{(i)}$	$\Delta\%\alpha_{\eta,d}^{(i)}$	$\Delta\%\alpha_{\eta,hy}^{(i)}$	$\omega_{\eta,d}^{(i)}$	$\Delta\%\alpha_{\eta}^{(i)}$	$\Delta\%\alpha_{\eta,d}^{(i)}$	$\Delta\%\alpha_{\eta,hy}^{(i)}$	$\omega_{\eta,d}^{(i)}$
DG:Chemicals	7.82	−0.11	10.63	26.16	6.36	−1.34	9.26	27.28	−0.36	2.44	−1.53	29.40	3.23	1.13	4.03	27.40
DD:Wood	7.56	4.73	10.01	46.37	5.45	2.87	7.72	46.73	3.42	5.06	1.85	48.88	2.82	2.02	3.53	47.72
DA:Food-Tobacco	6.61	7.16	6.49	18.45	2.59	−0.79	3.36	18.66	1.83	1.60	1.89	19.30	2.08	1.37	2.25	18.60
DL:Electr. Machinery	6.99	5.61	8.16	45.86	5.72	5.28	6.09	46.14	0.73	3.40	−1.67	47.32	2.07	1.41	2.64	46.02
DK:Machinery n.e.c.	6.56	5.22	7.28	34.99	5.85	3.73	7.04	35.99	1.03	3.30	−0.33	37.48	2.03	1.32	2.42	36.10
DC:Leather	11.39	7.19	14.14	39.57	5.18	3.31	6.34	38.47	−1.34	−1.33	−1.34	36.79	2.01	2.57	1.69	38.05
DH:Plastics	2.68	−1.94	5.92	41.21	7.11	7.76	6.69	38.69	1.68	−1.06	3.52	40.21	1.92	1.90	1.95	40.11
DB:Textiles	6.89	6.64	7.09	45.23	2.84	0.41	5.02	47.11	−0.71	0.23	−1.57	47.90	1.81	1.17	2.37	46.28
JJ:Finance	5.31	7.02	3.46	51.81	0.35	2.92	−2.23	50.00	5.33	2.16	8.35	48.64	1.73	2.71	0.74	50.00
II:Transport-Comm.	4.96	7.66	2.87	43.69	0.68	0.92	0.52	41.25	0.56	0.95	0.29	41.49	1.52	2.39	0.87	41.84
DM:Transport Equip.	7.87	8.83	7.47	29.12	−1.82	−5.45	−0.59	25.36	4.51	5.84	4.04	26.18	1.49	3.23	0.83	26.89
LL:Public Admin.	0.76	0.86	0.58	65.55	2.28	1.78	3.09	61.55	1.65	1.59	1.75	62.35	1.42	2.09	0.23	62.96
DN:Manufacture n.e.c.	7.82	6.27	8.84	39.81	4.40	0.60	7.17	42.09	0.94	1.43	0.58	42.33	1.37	0.61	1.89	41.56
DE:Paper-Printing	1.75	5.93	−0.76	37.56	3.53	3.28	3.69	37.65	1.09	1.86	0.62	38.02	1.22	1.46	1.07	37.70
DI:Non-met. minerals	5.80	4.05	6.98	40.29	2.66	3.80	2.00	36.59	−1.81	−2.56	−1.34	38.45	1.03	1.35	0.83	38.25
DJ:Metals	4.22	4.17	4.26	42.53	4.00	−0.21	7.14	42.64	−0.94	2.00	−3.12	42.48	0.89	1.15	0.70	42.47
AA:Agriculture	−1.95	−0.87	−4.67	71.56	5.18	9.79	−5.31	69.42	2.90	3.81	0.65	71.29	0.84	1.20	−0.07	70.89
NN:Health	1.19	0.16	4.05	73.58	0.55	1.83	−2.71	71.82	0.99	0.93	1.12	70.43	0.78	1.25	−0.42	72.17
MM:Education	−0.87	0.05	−7.22	87.26	0.47	0.80	−2.23	89.06	0.44	0.52	−0.20	89.99	0.46	0.06	3.68	88.79
CB:Mining non-energy	4.96	1.48	7.54	42.51	−6.92	−3.71	−9.00	39.30	−3.34	−4.12	−2.85	38.31	0.40	1.69	−0.46	40.03
GG:Trade	1.39	3.09	−0.54	53.09	1.64	2.61	0.66	50.49	0.85	1.52	0.17	50.42	0.11	1.13	−0.97	50.99
PP:Household Services	0.09	0.09		100.00	−0.11	−0.11		100.00	−0.02	−0.02		100.00	0.01	0.01		100.00
FF:Construction	1.82	1.00	2.62	49.41	1.26	−0.32	2.88	50.82	−1.70	−2.09	−1.28	52.11	−0.07	−0.68	0.57	50.67
HH:Hotel-Restaurant	2.35	0.93	4.12	55.54	−0.98	−1.45	−0.33	57.87	2.34	1.78	3.11	57.69	−0.41	−1.11	0.52	57.38
EE:Energy	−2.24	0.84	−3.28	25.27	11.97	4.18	13.83	19.23	−5.94	1.65	−7.69	18.74	−0.62	2.74	−1.56	20.89
BB:Fishing	13.63	14.00	11.99	81.65	−8.06	−8.40	−6.67	80.57	−2.52	−2.99	−0.19	83.38	−1.14	−0.80	−2.53	81.64
KK:Business Services	−1.06	−2.44	0.08	45.33	−2.07	−1.78	−2.33	45.73	−1.73	−1.97	−1.53	45.67	−1.47	−1.31	−1.61	45.47
OO:Personal Services	−3.70	−5.01	−1.95	57.17	7.93	5.79	10.89	57.89	0.38	0.68	−0.09	60.34	−1.55	−2.09	−0.76	58.08
DF:Coke-Petroleum	−3.40	−2.89	−3.52	19.83	−34.08	−1.25	−42.11	19.52	18.37	0.80	21.39	14.65	−7.07	−1.98	−8.35	18.44

Source: Own computation based on Supply-Use Tables (SUT) and National Accounts Data, ISTAT

References

EUROSTAT (2008). *Eurostat Manual of Supply, Use and Input-Output Tables*. European Communities, Luxembourg.

Harberger, A.C. (1998). A Vision of the Growth Process. *The American Economic Review*, 88(1):1–32.

Harrod, R.F. (1973). *Economic Dynamics*. Macmillan, London.

Inklaar, R. & Timmer, M.P. (2007). Of Yeast and Mushrooms: Patterns of Industry-Level Productivity Growth. *German Economic Review*, 8(2):174–187.

Pasinetti, L.L. (1959). On Concepts and Measures of Changes in Productivity. *The Review of Economics and Statistics*, 41(3):270–286.

——— (1973). The Notion of Vertical Integration in Economic Analysis. *Metroeconomica*, 25:1–29.

——— (1981). *Structural Change and Economic Growth — A Theoretical Essay on the Dynamics of the Wealth of Nations*. Cambridge University Press, Cambridge.

——— (1988). Growing subsystems, vertically hyper-integrated sectors and the labour theory of value. *Cambridge Journal of Economics*, 12(1):125–34.

——— (1989). Growing subsystems and vertically hyper-integrated sectors: a note of clarification. *Cambridge Journal of Economics*, 13(3):479–80.

——— (1998). A Note on Richard Stone's paper on Changes in Productivity. *Structural Change and Economic Dynamics*, (9):233–5.

Solow, R.M. (1957). Technical Change and the Aggregate Production Function. *The Review of Economics and Statistics*, 39(3):312–320.

Sraffa, P. (1960). *Production of Commodities by Means of Commodities*. Cambridge University Press, Cambridge.

Stone, R. (1998[1960]). Changes in Productivity. *Structural Change and Economic Dynamics*, (9):229–231.

Wolff, E.N. (1994). Productivity measurement within an Input-Output framework. *Regional Science and Urban Economics*, 24(1):75–92.