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\textbf{A B S T R A C T}

This paper studies the role played by ICT in affecting the efficiency of business services (BS) industry, using a structural disequilibrium model of the Italian economy. The Italian BS sector presents a peculiar dynamics (compared to other EU countries) in that, after initially improving its efficiency by adopting ICT, from the early 90s it stagnated. Our estimates suggest that this anomaly can be traced back to a structural deficiency in absorbing new technologies. Our contribution adds to the explanations of the slow down of the Italian productivity.

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1. Introduction

The “business services” definition covers a broad spectrum of heterogeneous activities (mainly traded in business-to-business transactions) that range from R&D, legal, professional and management consultancy, equipment rental, logistics, etc. In the OECD countries the Business Services (BS) industry grew much faster, over the last two decades, than other sectors, thus playing a fundamental role in enhancing economic growth (\textit{OECD}, 2007). In the early 80s most of these services were produced in-house. At the beginning of the 90s wide diffusion of the ICT contributed to the improvement in the efficiency of BS (\textit{Gallouj}, 2002; \textit{Gallouj and Savona}, 2009). The consequent reduction in transaction costs and in moving the production of services outside the firm was at the base of outsourcing of tasks and entire activities.

As stressed by the literature, ICT and BS are characterised by interactions and complementarity (\textit{Miles}, 2004). In the interaction between ICT and BS, the BS sector purchases and uses knowledge or equipment from ICT, manufacturing and other services; simultaneously, BS provides services to ICT and manufacturing, this way increasing their returns from specialisation.

In this paper we focus on the first part of this interaction. Specifically, we investigate what has been the effect of the combined impact of ICT and BS development on the Italian economic growth. In contrast to many studies of the BS sector which are of comparative statics nature, this paper specifically investigates the dynamic effects of productivity changes in the consolidated BS and ICT sector on the Italian production. Indeed, the model explores the dynamics of ICT and BS capital accumulation as well as their combined effect on the overall production.

The methodology uses a structural disequilibrium model. We assume that the market environment is one of imperfect competition where firms have similar production functions but different endowments and their products are sufficiently differentiated that they are monopolistic competitors in the short run, setting their
own prices. Thus they may set prices according to their marginal costs plus some mark-up or margin which will vary according to the elasticity of demand for their specific product.

It is also assumed that, at least in the aggregate, firms can vary the amount of unskilled labour to produce the required output relatively easily but with some costs such as those imposed by rigidities in the labour market or by regulation. Firms vary their skilled workforce more slowly, again particularly in the aggregate where such labour must be more highly trained or educated.

The model allows the marginal product of ICT capital and of skilled labour to differ between an all-purpose output and an ICT plus BS output (ICTB, from now onwards) so it helps determine whether such differences exist and, if so, the factors causing these differences.

Although the model has a traditional structure in that the resource endowments play a fundamental part in explaining technological choice, it has the following main distinguishing characteristics:

1. The model is designed to investigate the effects of the introduction of ICT technology on the Italian Business Services sector not in a partial equilibrium context of a single market (e.g., labour market) but from a macroeconomic point of view where capital (both of traditional and the innovative type) and (skilled and unskilled) labour markets interact;
2. An assumption of the model is that input markets clear instantaneously but rather that there are imperfections and frictions. In other words, the situation depicted by the model is one of disequilibrium dynamics.
3. In the model the economy does not necessarily converge to a steady state, as does much of the existing literature. Note that even if the model does not have a steady state and not be stable in a classical sense, it may still have an attractor and be stable.

Our main findings show that the Italian BS sector was initially favoured by the diffusion of ICT, mostly through the adoption of new hardware and software. The marginal products of capital show that by the end of the 80s and the beginning of the 90s, this improvement in efficiency came to a stop. Many factors contributed to this standstill but in our view it was caused mainly by the failure to adopt new forms of organisation needed to fully exploit the productivity enhancing potential. Furthermore, the slowdown of the BS growth rate beginning in the mid-90s appears to have held back the ICT producing industry and the wide-economy productivity growth.

The organisation of the paper is as follows. The next section provides the stylised facts featuring this sector in Italy. Section 3 synthetically describes the equations of the model. Section 4 discusses the estimates results. The last section concludes.

2. Stylized facts

Most BS nowadays can be found in the residual category “Other Business Services” that refers to a wide range of activities often closely related to the activities in other sectors. Table 1 gives a more detailed description of this sector by activity (with classification code NACE 74).1

Business services can be viewed as broader than summarised in Table 1 by including the following: renting of machinery and equipment (code 71), computer and related activities (code 72), and research and development (code 73). We choose not to include them in our analysis for two reasons. First, the focus of our investigation is on the role of ICT producing sectors on the efficiency of BS; given the proximity of the two activities, including sector 72 would have almost certainly implied duplication problems. Second, the weight of the sector 74 is by far the most relevant in the total value added by business services.

Although the ICT and BS sectors are to a large extent interdependent the dynamics of the two sectors differ substantially. The BS sector in Europe has experienced a remarkable growth process over the period 1980–2005, in terms of both employment and value added, with both annual growth rates averaging more than 4% (Rubalcaba and Kox, 2007). As we shall see below, Italy displayed a quite different pattern in the growth of the two sectors, at least since the middle of the 90s. Whilst the general slowdown has only partially affected the ICT sector, its impact on BS has been particularly relevant. At the same time, given its intimate connection with the rest of the economy, it is likely that BS negatively affected the dynamics of the economy.

Indeed, even before the recent financial crisis, the Italian economy showed only very modest growth, if not stagnation, in GDP (see Saltari and Travaglini, 2009). In the last thirty years the GDP growth rate has been on average a meager 1.4%. A wide consensus exists on the diagnosis of the chronic disease of the last period: it has been primarily due to a marked slowdown in labour productivity. There is also a large consensus that one of the factors contributing to this slowdown can be traced back to a weakening of the BS sector.

Fig. 1 shows the evolution of the ICT and BS shares on total value added over the period 1980–2005. The average shares of the two sectors over the whole sample period show a remarkable similarity (the BS average is something

---

1 NACE is the acronym for “Nomenclature statistique des activités économiques dans la Communauté européenne”.

---

### Table 1

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>74.11</td>
<td>Legal activities</td>
</tr>
<tr>
<td>74.12</td>
<td>Accounting, book-keeping and auditing activities; tax consultancy</td>
</tr>
<tr>
<td>74.13</td>
<td>Market research and public opinion polling</td>
</tr>
<tr>
<td>74.14</td>
<td>Business and management consultancy activities</td>
</tr>
<tr>
<td>74.15</td>
<td>Management activities of holding companies</td>
</tr>
<tr>
<td>74.20</td>
<td>Architectural and engineering activities and related technical consultancy</td>
</tr>
<tr>
<td>74.3</td>
<td>Technical testing and analysis</td>
</tr>
<tr>
<td>74.4</td>
<td>Advertising</td>
</tr>
<tr>
<td>74.5</td>
<td>Labour recruitment and provision of personnel</td>
</tr>
<tr>
<td>74.8</td>
<td>Miscellaneous business activities n.e.c.</td>
</tr>
<tr>
<td>74.81</td>
<td>Photographic activities</td>
</tr>
<tr>
<td>74.84</td>
<td>Other business activities n.e.c.</td>
</tr>
</tbody>
</table>
more than 6%, whilst the ICT mean share is less). Despite this similarity, their dynamics were surprisingly different.\textsuperscript{2}

In fact, the dynamics of these two sectors were strongly correlated until the deep recession at the beginning of the 90s. In the following years, BS fluctuated around 6%; by contrast, since the middle of 90s, ICT registered a strong recovery after the recession surpassing BS by the end of the period. There are two partly overlapping reasons to explain this diverging pattern.

The first reason is the introduction and diffusion of ICT technologies, as shown by the marginal products in the results below. At the beginning, these new technologies boosted the efficiency of BS, creating new business opportunities and favouring the shift of competencies outside the firm. The resulting increase in efficiency did not continue and came to a standstill. This is because the higher intensity of ICT technology was not associated to a re-organisation of the production process and to a redistribution of managerial tasks (Evangelista and Vezzani, 2010). Indeed, the productive use of ICT is strongly linked to various dimensions of non-technological innovations. The failure of BS sector to reorganise itself implied that its dynamics was dominated by macroeconomic factors affecting the whole economy.

3. The model

The theoretical model presented is based on Saltari et al. (2012) to which we refer for a more detailed description. The model distinguishes between a general output production function and one whose output is given by ICT plus BS. The joint output, ICTB, includes the three standard ICT sectors, namely office machinery, communications, software, and the business services sector.\textsuperscript{3}

The model is composed of seven equations representing the two production sectors: the output of the total economy \((Y)\) and the ICTB output \((I)\), both specified as CES technologies. \(Y\) is obtained through a combination of capital (both traditional and innovative, \(K\) and \(C\)), and labour, where the latter is defined as a geometric average with weights \((\gamma_s, \gamma_u)\) of skilled \((L_s)\) and unskilled labour \((L_u)\). The ICTB production function considers ICTB capital \((C)\) and only skilled labour with a specific labour augmenting factor with growth rate \(\lambda_C\). See Appendix A.1 for the definition of variables.

The two investment equations can be derived from the intertemporal optimisation of a profit function leading implicitly to a second-order distributed lag in the capital stock to a first-order function in investment.\textsuperscript{4} \(\alpha_2\) and \(\alpha_4\) are the rates of adjustment of the two capital marginal productivities \((\partial f_i/\partial K, \partial f_i/\partial C)\) to the respective user costs, whilst \(\alpha_1\) and \(\alpha_3\) describe the adjustment to the long run equilibrium growth rates \((\mu_K, \mu_C)\) of the two capital stocks. A similar specification is used in the determination of the employment of skilled labour (with a long run growth rate \(\lambda_K\)), as well as in that of unskilled wages (whose long run growth rate in efficiency units is the same of the general production function, \(\lambda_K + \gamma_1 \lambda_C\), the long run capital accumulation rate). Notice that, whilst skilled employment is assumed to be determined by the demand for labour, unskilled employment is ready to fill any shortfall in producing the required output, so that the pool of unskilled labour acts as a buffer. Finally, prices are determined according to marginal (labour) cost per unit of output, \(w\ (\partial L/\partial Y)\), derived from the inverse of the production function multiplied by indirect taxes \(\tau\) and with a mark-up \(\beta_{13}\). The price dynamics reflect the competitive process and the way in which prices are likely to be affected by the rates of change of real wages adjusted for increases in efficiency. The marginal cost of labour is obtained in the usual way as a ratio between the mean wage and the marginal product of labour, where labour is defined as seen above as a geometric average between skilled and unskilled labour.

The model is based on two production functions.

\textsuperscript{2} It is fair to recall the measurement problems present in the data regarding the BS sector that can hamper an adequate assessment of its performance. See Wolff, 2003.

\textsuperscript{3} The use of an ICTB sector as defined in this model implies that whilst it is possible to estimate and discuss the effects of the consolidated sector, the effects of business services cannot be evaluated separately from ICT. Indeed, data limitations mean that the specific effect of BS on ICT cannot be tested with statistical rigor but has to be inferred from the estimates of similar models. The combined impact of ICT and BS on general production can be tested properly.

\textsuperscript{4} A second order distributed lag function may be defined as:

\[x(t) = \int_{-\infty}^{\infty} f(s) x(t-s)ds\]

where \(f(s) = \frac{\alpha_2^s}{\alpha_2 + \alpha_4^s}\) (or, in differential operator form, \(x(t) = \frac{\alpha_2^s}{\alpha_2 + \alpha_4^s}\)), with \(\alpha > \beta > 0\), so that

\[D^2 x(t) = \alpha \beta \left( \widehat{x} - x(t) \right) - (\alpha + \beta) \ D x(t)\].

Note that in this form the designation of \(\alpha\) and \(\beta\) is arbitrary. If this formulation is compared with that used in the accumulation equations:

\[D^2 x(t) = \alpha \left[ \beta \left( \widehat{x} - x(t) \right) - D x(t) \right]\].

there is an additional constraint imposed on \(\alpha\) and \(\beta\).
The general production function

\[ Y = \beta_3 \left( (C \gamma_1 K)^{-\beta_1} + (\beta_2 e^{(\lambda_\kappa + \gamma_1 \lambda_\ell + K)} t L_t^{\lambda_\ell} L_t^{\lambda_K} - \beta_1)^{-1} \right) \]

(3.1)

In equation (3.1) \( \lambda_\kappa, \lambda_\ell \) are the rates of technical progress in the use of standard capital stock \( K \) and ICT capital \( C \). Their linear combination \( \lambda_\kappa + \gamma_1 \lambda_\ell \) is the growth rate of labour efficiency, \( \beta_2 \) is the labour augmenting technical progress, whilst \( \beta_3 \) is a measure of the total factor productivity. The efficiency of traditional fixed capital stock is augmented by ICT capital, \( C \), with a weighting factor equal to \( \gamma_1 \); the elasticity of substitution is given by \( \epsilon_1 = 1/(1 + \beta_1) \).

The ICTB production function

\[ I = \beta_6 \left[ C^{-\beta_4} + (\beta_5 e^{\lambda_\ell t} L_{t+s})^{-\beta_4} \right]^{-1/\beta_4} \]

(3.2)

In Eq. (3.2), \( \beta_5 \) is labour augmenting technical progress, whilst \( \beta_6 \) is a measure of TFP. The elasticity of substitution is \( \epsilon_3 = 1/(1 + \beta_6) \).

These equations lead to the specification of a structural model of general and ICTB investments, the skilled and unskilled labour sectors, and price determination:

1. Investment functions
   (a) Traditional capital

\[
\dot{k} = \alpha_1 \left[ \alpha_2 \left( \frac{\partial f}{\partial K} - (r - \beta_7 D \ln p + \beta_8) \right) - (k - \mu_K) \right]
\]

(3.3)

(b) ICT capital

\[
\dot{\ell} = \alpha_3 \left[ \alpha_4 \left( \frac{\partial f_i}{\partial C} - (r - \beta_8 D \ln p + \beta_{10}) \right) - (\ell - \mu_\ell) \right]
\]

(3.4)

where in Eq. (3.3) \( \mu_K = \lambda_\kappa + (\gamma_5 - \gamma_1) \lambda_\ell + \gamma_6 \lambda_w \) and in Eq. (3.4) \( \mu_\ell = \lambda_\kappa + \lambda_\ell \).

2. Skilled demand
   (a) Demand for skilled labour

\[
\dot{\ell}_s = \alpha_5 \left[ \alpha_8 \ln \left( \frac{\partial f_i}{\partial L_s} \right) \left( \frac{w_s}{p} \right) \right] + \alpha'_6 \ln \left( \frac{\partial f_i}{\partial L_s} \right) \left( \frac{w_s}{p} \right) - (\ell_s - \lambda_s)
\]

(3.5)

(b) Determination of skilled nominal wages

\[
D^2 \ln w_s = \alpha_7 [\alpha_8 \ln \left( \frac{\partial f_i}{\partial L_s} \right) \left( \frac{w_s}{p} \right) + \alpha'_6 \ln \left( \frac{\partial f_i}{\partial L_s} \right) \left( \frac{w_s}{p} \right)] - (\alpha_7 + \alpha_8 + \alpha'_6 \ln \left[ \frac{D \ln w_s - \beta_{11} D \ln p - \lambda_\kappa - \gamma_1 \lambda_\ell}{D \ln p - \lambda_\kappa - \gamma_1 \lambda_\ell} \right])
\]

(3.6)

3. Unskilled labour
   (a) Employment

\[
\dot{\ell}_u = \alpha_9 \alpha_{10} \ln \left( \frac{L_d^u}{L_u} \right) - (\alpha_9 + \alpha_{10})(\ell_u - \lambda_u)
\]

(3.7)

(b) Determination of unskilled wages

\[
D^2 \ln w_u = \alpha_{11} \left[ \alpha_{12} \ln \left( \frac{L_d^u}{L_u} \right) - (D \ln w_u - \lambda_\kappa - \gamma_1 \lambda_\ell) \right]
\]

(3.8)

where \( L_d^u = L_u \left( \frac{w_u}{p_u} \right)^{\delta_{12} e^{\lambda_\ell t}} \). In the model, changes in the unskilled labour supply depend on the real wage, with elasticity \( \beta_{12} \). Thus, the effect on labour supply will be largely symmetrical at the margin for increases and decreases of real wages. However this is only one side of the labour market. We should also take into account the demand side. Unless the elasticity of real wages in the supply function is one, changes in nominal wages have a differing effect on prices and hence on real wages. The price effect then feeds back into investment, capital, and thus on the demand for labour via its marginal product. The effect on the capital stock is not symmetric but this is slow acting.\(^7\)

4. Price determination

\[
D^2 \ln p = \alpha_{13} \alpha_{14} \ln \left( \frac{\beta_{13} \tau}{mc} \left( \frac{\partial L}{\partial Y} \right) \right) + (\alpha_{13} + \alpha_{14}) D \ln p + \alpha_{15} \left( \frac{D \ln (w_s/p)}{-\lambda_\kappa - \gamma_1 \lambda_\ell} \right)
\]

\[
+ \alpha_{16} \left( \frac{D \ln (w_u/p)}{-\lambda_\kappa - \gamma_1 \lambda_\ell} \right)
\]

\[
+ \alpha_{17} \left( \ln \left( \frac{M}{p \nu} + u + \lambda_u \nu \right) \right)
\]

(3.9)

where \( \beta_{13} \) is the mark-up and \( mc (\partial L/\partial Y) \) is the marginal cost determined as follows

\[
mc \left( \frac{\partial L}{\partial Y} \right) = \left( \frac{w_s L_s + w_u L_u}{\gamma_s} \right) L_t^{\gamma_s} L_t^{\gamma_u} (\beta_2 \beta_3)^{-1}
\]

\[
\times e^{(\lambda_\kappa + \gamma_1 \lambda_\ell) t} \left( 1 - \frac{Y}{\beta_3 \lambda_\kappa} \right)^{(1+\beta_1)/\beta_1}
\]

Further, \( \nu = \ln \left( \frac{L}{L+\nu} \right) - \ln \bar{M} \) is the mean velocity over the sample and is assumed to vary at a rate \( \lambda_\nu \), with

\(^6\) Estimates of \( \beta_{11} \) were not significantly different from 1 showing there is no money illusion in the determination of real wages. In the final model \( \beta_{11} \) was set to 1.

\(^7\) Behind Eq. (3.8), there is the idea that real wage reacts to labour demand and supply discrepancies. Empirically, this implies the existence of a relationship between wage and employment – the so called “wage curve”. This topic is much debated in the literature. With reference to our sample period, we can distinguish two subperiods. In the first half, which goes up to the early 90s, empirical estimates do not find evidence of such a wage curve (see Lucifora and Origo, 1999). In the second half, beginning after the July Income Policy Agreement, there is a clear empirical evidence supporting the wage curve relationship (see Devicienti et al., 2008).
Table 2
Parameter estimates.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Estimates</th>
<th>Asymptotic standard errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_1$</td>
<td>0.5554</td>
<td>0.1512</td>
</tr>
<tr>
<td>$e_{1} = \frac{1}{\lambda T}$</td>
<td>0.6429</td>
<td>0.0625</td>
</tr>
<tr>
<td>$\beta_2$</td>
<td>1.7735</td>
<td>0.6213</td>
</tr>
<tr>
<td>$\beta_3$</td>
<td>7.9885</td>
<td>2.5009</td>
</tr>
<tr>
<td>$\beta_4$</td>
<td>0.9888</td>
<td>0.1433</td>
</tr>
<tr>
<td>$e_{4} = \frac{1}{\lambda T}$</td>
<td>0.5028</td>
<td>0.0362</td>
</tr>
<tr>
<td>$\beta_6$</td>
<td>6.2764</td>
<td>1.5899</td>
</tr>
<tr>
<td>$\beta_{10}$</td>
<td>0.0030</td>
<td>0.0028</td>
</tr>
<tr>
<td>$\beta_{12}$</td>
<td>0.0596</td>
<td>0.0272</td>
</tr>
<tr>
<td>$\beta_{13}$</td>
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</tr>
<tr>
<td>$\gamma_{1}$</td>
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<td>0.0336</td>
</tr>
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<td>$\gamma_{4}$</td>
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<td>0.0300</td>
</tr>
<tr>
<td>$\gamma_{f}$</td>
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<td>0.0071</td>
</tr>
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<td>$\lambda_{x}$</td>
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<td>0.0054</td>
</tr>
<tr>
<td>$\lambda_{C}$</td>
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</tr>
<tr>
<td>$\lambda_{x}$</td>
<td>0.0026</td>
<td>0.0014</td>
</tr>
</tbody>
</table>

more efficient transactions and an increase in the use of electronic money.  

4. Estimation results

Estimates of the parameters were found by the Gaussian estimator of the non-linear model subject to all constraints inherent in the model, using a sample from 1980/Q2 to 2005/Q1. The observation period is one quarter, so all flows, such as $Y$, $I$ and derivatives of variables, as well as wage and interest rates are all quarterly. All parameters $\alpha$ and $\lambda$ have a quarterly interpretation, but many of the parameters $\beta$ and $\gamma$ are elasticities and hence dimensionless.  

Table 2 shows the parameter estimates. See Appendix A.2 for data sources.

We will focus on those parameters estimates which help in enlightening the role played by BS and ICT on the overall economy. To this end, let us concentrate on the ICTB production function – Eq. (3.2). The relevant parameter estimates are $\beta_4$, $\beta_5$ and $\beta_6$. To better understand their significance, it is useful to compare them with the values estimated from a previous version of the model which does not include BS. These estimates are reported in Table 6 (see Appendix B). Let us begin with the elasticity of substitution, which is given by $1/(1 + \beta_4)$. The magnitude of the elasticity with BS is less, going from 0.57 to 0.50. Interpreting the elasticity as a measure of efficiency (de La Grandville, 2008) suggests that the combination of BS with ICT was not able to exploit new combinations of capital–labour intensity offered by the technical opportunities arising from ICT innovations.

This lack of adaptability emerges also if we look at $\beta_5$, a measure of labour intensity in the ICTB sector. The comparison of $\beta_5$ in the two cases shows that the efficiency of skilled labour decreases, more than halving its value. For empirical evidence confirming this finding, see Kox et al. (2004) and Fixler and Siegel (1999).

Whilst the higher value of $\beta_6$ could be explained by the presence of BS having a beneficial effect on TFP (and similarly with $\beta_5$), this is partly a scaling effect. Unlike several other studies (Hempell et al., 2002; van Leeuwen, 2008; Baker and Miles, 2008), it is not clear that aggregate production as well as the ICT industry have benefited from the introduction of BS.

Table 3 shows the marginal productivities of the two capital inputs, traditional and innovative in the general production, both for the whole period and for each half; in addition, the last column reports the marginal productivity of the innovative capital in the ICT production. Table 4 shows the same variables without the BS sector. Incidentally, it was at mid-point of the sample around 1992 that there was a change in the dynamics of value added of ICT and BS sectors; the contribution of value added by BS showed a marked drop and a stagnation afterwards.

Two interrelated factors contributed to this dynamics: a slowdown related to the weakness of performance of the Italian economy and the specific failure of BS to adopt new forms of organisational systems to take advantage of the introduction of the new technologies. This is clearly shown by looking at the dynamics of the marginal productivities provided in the two tables. Several facts are worth noticing.

Table 3
Capital marginal productivities (quarterly average in percentage).

<table>
<thead>
<tr>
<th>(with BS)</th>
<th>MP$_{y}$</th>
<th>MP$_{e}$</th>
<th>MP$_{c}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981–2004</td>
<td>0.39</td>
<td>1.5</td>
<td>1.9</td>
</tr>
<tr>
<td>1981–1992</td>
<td>0.41</td>
<td>1.8</td>
<td>2.4</td>
</tr>
<tr>
<td>1993–2004</td>
<td>0.38</td>
<td>1.3</td>
<td>1.4</td>
</tr>
</tbody>
</table>

8 It is clear, however, both from preliminary estimates and the sample data that over the sample period $\lambda_{x}$ is close to zero.

9 The WYSEA software was used in the estimation. See Wymer, 2006.

10 A similar consideration can be made about $\beta_5$ (with and without the BS sector).

11 A deeper investigation of these effects requires re-specifying the production functions with BS as a specific intermediate input, a task left to future research.

12 Marginal productivities of the traditional and innovative capital in the general production function are:

$$\frac{\partial Y}{\partial C} = \beta_4 \gamma f \left( \frac{Y}{\beta_3 Y C \gamma} \right)^{1+\beta_1}$$

$$\frac{\partial Y}{\partial C} = \beta_5 \gamma f Y K C^{-1} \left( \frac{Y}{\beta_3 Y C \gamma} \right)^{1+\beta_1}$$

whilst that of the ICT production function is:

$$\frac{\partial Y}{\partial C} = \beta_6 \left( \frac{1}{\beta_6 C} \right)^{1+\beta_1}$$

where $\beta_1$ and $\gamma_1$ are the estimated values.
is apparent: its value is lower both in the whole period and in the two sub-periods. Whilst the data shows the average productivity of BS is high through most of the period, a comparison of marginal products of the two models (with and without BS) show that BS reduced the marginal products of both traditional and innovative capital in both production functions.¹³ In fact, the failure of BS to add to the efficiency of the ICT sector is evident by comparing the productivity without BS which is greater by a factor between 3 and 4 than ICTB. Thus, the ICT industry, differently from what emphasised in the literature, does not benefit from the BS industry. The literature offers many explanations of BS providing at least a modest contribution to the efficiency of ICT industry and suggests the falling of BS prices may favour industries other than ICT (Barone and Zingano, 2008; Oulton, 2001) and/or the BS sector generates positive technology spillover effects to the rest of the economy (van Leewen, 2008; Hempell et al., 2002; Baker and Miles, 2008). Empirical evidence confirms such a finding (Camacho and Rodriguez, 2007; Guerrieri et al., 2005). The results of the estimates of the model in this paper, and in Saltari et al. (2012), must raise doubts about these conclusions. One crucial factor could be the distinction between marginal and average productivities and their effects on the economy.

The observation that the contribution of BS to production is at best modest is strengthened by a comparison of labour efficiency growth rates in the two sectors. In the ICT sector, the labour efficiency (λC) falls from 3.6% without BS to 2.1% when BS is included. On the other hand, the labour efficiency (λK + γ1 λC) increases from 0.3% to 0.4% once BS is included. This supports the general view that, as far as labour is concerned, the kind of the BS services produced may have been relatively more applicable to the traditional production than to the innovative one.

One fact that may be important in this comparison is the large differences in the use of high-skilled labour between the ICT and BS sectors. Although the model does distinguish between skilled and unskilled labour, these definitions are very broad and a more well-defined measure of human capital may be more relevant in the analysis of the effects of BS on the economy.

We will now look at the dynamics of NDP through the period 1980:4–2004:3 and restrict our attention to the analysis of the core of the model, in order to compare the theoretical net output to the observed one, as in Fig. 3.¹⁴ The former is obtained using the production function specified in (3.1) with the estimated values of parameters (β₁, β₂ and β₃). This procedure implies that there are no adjustment costs, or in other words, that the adjustment speeds are infinite so that this level of output can be considered “optimal”. The theoretical evolution of the NDP is then compared with the actual one.

As is clear from the graph, the gap between the observed and the estimated evolution of NDP is quite wide although that reduces in the mid-nineties; it begins to enlarge, but less so excluding BS, in the first decade of this century. The gap signals the existence of structural inefficiencies or at least long term costs some of which are costs of adjustment. Of course, some of these will always exist but others may really be unnecessary or excessive but may have become institutionalised. These adjustment costs, be they avoidable or not, are represented in the model through the parameters α (see below).

4.1. Structural stability

Dynamic simulations of the model suggest it does not fit the data well during the recession in the early 1990s and this had continuing effects. Given the severity of the recession, it is possible that there was a change in some structural parameter values during that period. A slightly modified model gives evidence of such a change but limitations in the data mean that this result must be considered as tentative. The model was re-estimated with a selected set of parameters replaced by θ + δθ, where δ is a dummy variable equal to 1 from 1992 and zero elsewhere. Thus, δθ is the change in the value of θ during the latter part of

<table>
<thead>
<tr>
<th>Year</th>
<th>MPK</th>
<th>MPL</th>
<th>MPU</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981–2004</td>
<td>1.71</td>
<td>5.1</td>
<td>4.6</td>
</tr>
<tr>
<td>1981–1992</td>
<td>1.76</td>
<td>6.4</td>
<td>5.7</td>
</tr>
<tr>
<td>1993–2004</td>
<td>1.66</td>
<td>3.9</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Table 4
Capital marginal productivities (quarterly average in percentage).

Fig. 2. The dynamics of marginal products.

Fig. 3. The dynamics of NDP (quarterly data in bn, actual and estimated).

¹³ The average product of capital in the ICT sector without BS was 0.19, including BS was 0.34, and of BS alone 0.69.
¹⁴ For completeness, we have also inserted in the graph the estimated NDP without the BS sector, derived from Saltari et al. (2012).
the sample. For the three parameters \( \ln(\beta_2) \times \beta_4 \) and \( \lambda_K \) the estimates of corresponding changes \( \ln(\beta_2) \times \beta_4 \) and \( \lambda_K \) – are all negative and jointly significantly different from zero at the 5% level. The Wald statistic of the hypothesis that the more constrained model where these parameters are jointly zero, that is there is no change in the parameters in the two parts of the sample, cannot be rejected at the 1% level.\(^{15}\) If a wider range of parameters are allowed to change, including \( \beta_1 \) and \( \beta_3 \), the joint hypothesis that all these are zero must be rejected. A dynamic simulation of the model with the estimated values for \( \ln(\beta_2) \times \beta_4 \) and \( \lambda_K \) but with all other parameters unchanged was closer to the observed path than the original model which supports the view that there was a structural break, at least to the extent of a change in some parameter values, around that time.

To confirm this result, we run a number of other simulations and calculations of the value of the production functions. These showed that increasing parameters \( \beta_2 \) and \( \beta_4 \) by 5% increased the value of the production functions for ICTB and general output, with no immediate and only slow later effects on the marginal product of capital \( K \) or \( C \) in the general production function and a fall in the marginal product of ICTB capital in the production function for ICTB output. As can be seen from the production function, Eq. (3.1), it is only as capital \( K \) or \( C \) changes that the marginal product of capital in the general production function changes. The marginal product of labour in both production functions is affected directly. Thus, if there were a structural change as detected above it was to the detriment of the economy.

### 4.2. Adjustment speeds

The fact that the inclusion of BS dragged down the general performance of the ICT sector and of the overall economy may be an Italian anomaly different from other EU15 countries where BS triggered productivity growth (see European Commission, 2009). Whether this is in fact an anomaly depends on the distinction between average and marginal products. The weaknesses of BS in the Italian economy can be traced back to the small size of firms operating in this sector (for a recent contribution on this theme, see Bugamelli et al., 2011)\(^{16}\) and excess of regulation in these markets, which decreases the efficiency and the competitive firm selection in the sector (Kox et al., 2010). A measure of regulation in the labour market is the employment protection legislation (EPL). This was included in the model as a nonlinearity in the adjustment coefficient \( \alpha_0 \) in the unskilled employment equation which was redefined as \( \alpha_0 + \alpha'_E/EPL \). \( \alpha'_E \) is significant but very small, indicating that an increase in EPL increases the rate of adjustment of unskilled labour to its partial equilibrium level.

Although the present model assumes that adjustment in the labour market is symmetric, it could be re-specified to allow some form of hysteresis or asymmetry, for instance by allowing the speeds of adjustment to differ depending on whether there is excess demand or supply in the market.

Table 5 reports the estimated speeds with which variables adjust to their long run values: the lower the alphas the slower is the adjustment process and the stronger the frictions.\(^{17}\) These frictions may reflect factors such as employment protection legislation, costs of adjustment or market product regulation.

We briefly discuss the parameters which are affected by the inclusion of BS in our model. The speed with which the marginal product of ICT capital adjusts to its user costs and risk premium (\( \alpha_4 \)) is lower when we include the BS sector (0.4) than without it (0.51). This implies that it takes longer time to adapt the actual ICT capital to the desired one. The rate of adjustment of skilled wages in the combined ICTB sector (\( \alpha'_E \)) to labour marginal productivity is lower (0.0015 vs 0.002), so the labour market in ICT appears to be more sticky when considering BS. Once again, these adjustment lags can be interpreted as signals of the inefficiencies present in the Italian BS sector commented above.\(^{18}\)

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\(^{15}\) The Wald statistic, which was 8.9, has Chi-square distribution with 3 degrees of freedom; the critical value at the 5% level is 7.8 and at 1% level 11.3. Alternatively, the model in the original form could have been estimated for each half of the sample but although the sample size was large enough for the two (part-sample) likelihood functions to exist, it was not sufficient to provide a reasonable approximation to their asymptotic properties. This provides a test of the hypothesis of a structural change in any (or all) of the parameters of the model.

\(^{16}\) We intend to investigate this question specifically with the use of a model which distinguishes the behaviour of firms by size, but the results of the model in this paper are consistent with the explanation above.

\(^{17}\) The reciprocal of the adjustment speed can be interpreted as the mean time lag, i.e. the time needed to eliminate the 63% of the discrepancy between actual and equilibrium values (see Wymer, 1997).

\(^{18}\) Note it is not possible to test the distinction between the model with and without the business service sector, as this changes the endogenous variable \( C \) and the exogenous variable \( I \). Thus, the likelihood function changes even with the same set of parameters. The models are not nested so any form of likelihood ratio test is not applicable.
5. Conclusion

In this paper we investigated the impact of ICT and BS on the performance of the Italian economy over the period 1980–2005. A preliminary analysis of the value added shares showed the existence of two distinct time-period dynamics. The first was characterised by a relevant correlation between the two sectors which can be interpreted as an indication of the gains obtained by BS in introducing ICT technological innovations. In the second, after the 90s recession, the BS stagnated whilst ICT recovered at a rapid pace. We also performed an analytical test of structural stability revealing the existence of a regime break at the beginning of 90s.

Our disequilibrium model provided an interpretation focussed on the impact of ICTB on aggregate production. Although the model does not allow us to evaluate the BS effects separately from those of ICT, some tentative conclusions can be drawn comparing the estimates of the present model with those of the model without BS. The structural parameters governing the ICTB production function support two characteristics of the Italian experience: the positive effect of the BS industry on the aggregate production – as evidenced by the high value of the efficiency parameters and the lack of adaptability by the BS to the new possibility frontier – highlighted by the low values of the elasticity of substitution and of the marginal capital productivities. These findings appear in line with the stylized facts regarding the well known weaknesses of Italian production structure.

Acknowledgments

We are grateful to two anonymous referees for many useful comments and suggestions that allowed us to improve the paper substantially. Enrico Saltari gratefully acknowledges financial support from the MIUR – PRIN project 2008YYBH7L.

Appendix A.

A.1 Definition of variables

+ $K$: fixed capital stock (real terms)
+ $C$: ICT capital stock (real terms)
+ $L_s$: skilled employment
+ $L_{ss}$: (skilled) employment of ICT sector
+ $L_u$: unskilled employment
+ $Y$: output (real terms)
+ $I$: output of ICT (real terms)
+ $p$: GDP price deflator
+ $p_I$: ICT price deflator
+ $r$: nominal interest rate
+ $w_s$: skilled real wage rate
+ $w_u$: unskilled real wage rate
+ $M$: volume of money (M2)
+ $k$: $D\ln(K)$
+ $l$: $D\ln(L)$
+ $t_s$, $t_u$: stochastic trends of skilled and unskilled labour force
+ $\lambda_K$, $\lambda_C$: rates of growth of technical progress in the use of traditional and ICT capital
+ $\lambda_s$, $\lambda_u$: rates of growth of skilled and unskilled labour force
+ $\tau$: indirect tax rate

A.2. Data used in the estimation

The data used in this study are of the Italian economy, quarterly from 1980:Q2, to 2006:Q1. GDP and NDP, fixed Capital, and total remuneration (“wages”) are defined as € bn., employment in millions of employees, any parameters of variables such as interest rates, rate of time preference, rates of growth, etc. as rates per quarter in natural numbers (for instance, 10% per annum is represented throughout this study as 0.025). All real variables are defined with base year 2000 (so that the GDP deflator used in preparation of the data has mean value 1.0 in 2000).

All logarithms are to base e.

The stock of fixed capital is calculated from net capital formation (gross capital formation less fixed capital consumption or depreciation) divided by the GDP deflator and accumulated from a base stock of 3572.4 (€ bn.) in 2000:Q2. The ICT capital stock is calculated from annual data for gross real investment less depreciation for each of three sub-sectors (ICT machines, telecommunications and software), each separately interpolated to provide quarterly observations, and total net investment cumulated on a base figure of 80.717 (€ bn.) in 2000:Q4.

The time trend has been defined with value 0.0 at the mid-point of the sample (so the mean of $t$ is zero) to simplify linearisation without affecting the properties of the model. All series have been transformed to eliminate (to an approximation) the moving average process inherent in discrete data generated by a continuous system as discussed in Wymer (1972).

- Total employment: Ameco, European Commission
- Average Hours: OECD
- Real gross Investment 2000: Istat
- Real Depreciation 2000: Istat
- Net Investment 2000: Istat
- Net Capital stock 2000: Istat
- Short interest rate: OECD
- Long interest rate 10 years: OECD
- Inflation by deflator: OECD
- Total labour cost: OECD (seasonal adjusted)
- GDP 2000: OECD
- Gross Investment 2000: OECD
- Value added ICT, BS and all industry total: EU-Klems
- ICT investment and Capital: Istat
- Compensation per employee: Ameco
- Compensation - ratio of skilled to unskilled labour: EU-Klems
- Skilled and unskilled labour: EU-Klems
- EPL index: OECD
- GDP Deflator: Istat
- Money Supply (M2): Banca d’Italia
- Indirect taxes: Istat
### Appendix B.

**Table 6**
Parameter estimates without BS (source Saltari et al., 2011).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Estimates</th>
<th>Asymptotic standard errors</th>
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<tbody>
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<td>$\beta_1$</td>
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<td>0.045</td>
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<td>$\epsilon_1 = \frac{1}{1 + \frac{\beta_1}{\beta_2}}$</td>
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<td>$\beta_3$</td>
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<td>$\beta_6$</td>
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<td>$\lambda_o$</td>
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<td>0.002</td>
</tr>
</tbody>
</table>

Log-likelihood of 2nd order unrestricted linear model = 4059

Log-likelihood of estimated non-linear model = 4163

### References


