

Productivity and labor in the business cycle: evidence from firm-level data

*Produttività e occupazione nelle fasi cicliche:
un'analisi su dati a livello d'impresa*

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Riassunto: usando dati panel a livello d'impresa vengono utilizzate tre metodologie alternative per misurare la produttività. Qualunque sia la misura prescelta, nel breve periodo la produttività risulta avere un impatto negativo sull'impiego di lavoro. Utilizzando dati sulla frequenza delle revisioni dei prezzi delle imprese, possiamo interpretare tale effetto negativo come dovuto alla diffusa presenza di rigidità nei prezzi.

Keywords: Productivity, Labor.

1. Introduction

Business cycle models are typically evaluated on the basis of their ability to match patterns of comovements observed in the data of selected macroeconomic variables. Recently, Gali (1999) has documented for the U.S. and other G7 economies a negative correlation between technology shocks and several measures of labor and other inputs. He interprets this finding, which is hard to reconcile with the predictions of a flexible-price model, as evidence in favor of sticky-price models. The argument is that in the wake of a productivity expansion, nominal rigidities prevent prices from falling and thus aggregate demand does not increase; on the other hand, firms produce the same amount of output with a smaller volume of inputs, which have become more productive.

However, Dotsey (1999) shows that if the central bank follows the optimal monetary policy or a Taylor rule, then the effect of technology shocks on employment is no longer negative, even if price stickiness prevails. With these specifications of monetary policy, flexible-price and sticky-price models are therefore observationally equivalent with respect to the predicted correlation between productivity shocks and labor input. Overall, these results imply that economies where monetary policy is well characterized by money growth pegging or any other rule failing to fully respond to technology shocks provide a good basis for assessing the empirical relevance of flexible- versus sticky-price models. In this regard, we believe that the Italian economy in the second half of the eighties and the first half of the nineties provides a very interesting case. In that period, Italian monetary policy was severely constrained by German monetary policy in order to ensure maintainance of the exchange rate margins. Therefore, in the wake of a domestic productivity shock Italian monetary policy has been less accommodative than, for example, under a standard Taylor rule.

These considerations motivate our empirical investigation of the relationship between productivity shocks and labor inputs in the Italian economy in the period mentioned. For this purpose, we use highly detailed panel data of a representative sample of manufacturing firms for the period 1984-1997. The use of microeconomic panel data prevents individual idiosyncrasies from being washed out in the aggregation process, thus avoiding a potentially serious bias in the estimates.

We derive three alternative measures of productivity variation: the first one is derived by employing a semi-parametric estimator for the production function parameters that takes explicit account of the self-selection induced by the shutdown decision (Olley and Pakes, 1996). The second measure is obtained from a theoretical model based on a dynamic cost minimization set-up that controls for imperfect competition, increasing returns, and variable intensity in the use of labor and capital. The third measure of productivity is the standard revenue-based Solow residual. We study the impact of a productivity improvement on labor inputs and find that, unambiguously, a negative relationship emerges from our data. Moreover, a notable feature of our data, namely the information on the frequency and size of price revisions of each firm, allows us to investigate the interpretation of this finding based on the existence of nominal rigidity. We find that the negative relationship between input use and productivity change is indeed much stronger for firms whose product prices are stickier.

2. The data and the alternative measures of productivity

We rely on firm-level data for a representative sample of Italian manufacturing firms drawn from two main sources: the Bank of Italy's Survey of Investment in Manufacturing (SIM) and the Company Accounts Data Service reports. Merging the information from the two sources resulted in an unbalanced panel of slightly fewer than 1,000 firms, which was used in the estimation process. Data range from 1984 to 1997.

In order to evaluate the impact of a productivity improvement on labor, we compute three different measures of the former variable. First, we adopt the method of Olley and Pakes (1997), that controls for both the selection problem induced by the relationship between the unobserved productivity variable and the liquidation decision and the endogeneity problem generated by the relationship between input demands and productivity. The algorithm is articulated in three steps. The first step is the estimation of a semi-parametric regression model stemming from a production function, which identifies the parameter associated to labor but not those associated to capital and the firm's age. To identify these latter parameters, we employ, in addition to the estimates obtained from this equation, the estimates of the survival probabilities obtained from a panel data probit estimation (second step). The final step takes the estimates from the previous two steps and uses them in a nonlinear regression where the dependent variable is the difference between (the log of) output and (the log of) labor, the latter pre-multiplied by its parameter b_l . Nonlinear least square estimates of the parameters provide all the ingredients for computing a "robust" firm-level measure of productivity.

Second, we apply the Basu and Kimball (1997) approach for measuring productivity to our microeconomic data. We formulate a dynamic cost minimization set-up that controls for imperfect competition, increasing returns, and variable intensity in the use of labor and capital. This leads to an empirical specification whereby productivity changes can be obtained. Estimations are conducted using the generalized method of moment (GMM) estimator for panel data. This method has been shown to be efficient

within the class of instrumental variable procedures, as it optimally exploits all linear moment restrictions following from the assumptions made on the error terms. Finally, we measure productivity by computing for each firm the standard Solow residual.

3. The impact of productivity changes on labor input

Above we have provided motivation for investigating empirically the correlation between productivity change and labor inputs. In this section, we present the results obtained by regressing labor input on several measures of productivity change. The overall evidence lends strong support to the hypothesis that, on impact, the effect of a technology change on labor input growth is negative (Tab. 1). This result holds for each of the alternative measures of productivity that we have computed. For example, when we regress total hours growth on $dp2$, the regression coefficient is $-.084$, with a standard error of $.023$ (it is $-.275$ with a standard error of $.028$ if $dp3$ is used). A similar result is obtained when the dependent variable is the growth in the number of employees, ($-.096$; s.e.: $.016$). We also estimated other panel regressions where the dependent variables are the same as before but lags of the productivity variables are added as regressors. While the coefficients associated with the lagged regressors are generally positive, suggesting a recovery over time in input growth, those associated with the contemporaneous change in technology remain negative and statistically significant in most cases, providing further support for the view that productivity improvements are contractionary in the short run. Arguably, the negative relationship found between input growth and productivity might be spuriously driven by some relevant economic variable, on either the demand or the supply side, omitted from the analysis. To tackle this issue, we inserted in the regressions a proxy of the firm's economic activity, such as the growth rate of firm's sales or sectoral output. In both cases the results remain substantially unchanged. All these empirical results point towards models of business fluctuations consistent with a decline in labor use in response to a positive technology shock. Our evidence dovetails with that recently reported by other contributions and can be interpreted as evidence in favor of sticky-price macroeconomic models.

If price stickiness drives our results, we should observe that, on average, the stickier the prices set by a given firm, the stronger would be the contractionary effect of a technology shock. Very interestingly, the SIM database includes firm-specific information on the frequency and size of price variations. With regard to frequency, in the 1996 survey firms were asked the following question: "How frequently does your firm typically modify selling prices?". This information from the SIM database allows us to conduct a test on the effects of technology shocks. We split the overall sample according to the frequency of price revisions reported by each firm, and examine whether the response of labor growth to a change in technology differs across the two samples. The evidence largely supports the view that, for firms with stickier prices, productivity shocks have a contractionary impact effect on input (Tab. 2). Conversely, for firms whose prices are less sticky the effect is weaker or not statistically significant. For example, if change in total hours is considered, the estimated effect of $dp2$ in the sample of firms with stickier prices is $-.248$; it is $.021$ in the other (with standard errors equal to $.035$ and $.052$, respectively). Arguably, specific features of a given market or product may cause, *ceteris paribus*, a higher or lower frequency of price revisions. Hence, we also split the sample according to whether the price stickiness of each firm, computed from the answer to the SIM question, was greater or smaller than the sectoral

median (or mean). The results (not reported) are very similar to those presented above. Furthermore, we also run separate regressions for each of the five groups of firms corresponding to each of the possible answers to the above question. The results broadly confirm the pattern depicted in Tab. 2. We also devised an alternative criterion for splitting the sample, based on the size of price revisions. In particular, we used information on annual price variations as reported each year by every firm. We split the sample according to whether a given firm has maintained its selling prices unchanged for one or more years rather than revising them every year. We therefore included in one sub-sample the firms that reported an annual price variation equal to zero for at least one year, and included all other firms in the other sub-sample. Table 3 presents the estimation results from this exercise. The main findings illustrated before are confirmed: the evidence supports a negative and statistically significant impact effect of technology change on input growth only in firms characterized by stickier prices.

Table 1: Estimating the impact of labor to several measures of productivity changes

Dependent variables	Alternative measures of productivity changes as Regressors		
	dp1 (Olley-Pakes)	dp2 (Basu-Kimball)	dp3 (Solow residual)
dlog(Total hours)	To be verified (t.b.v.)	-.084 (.023)	-.275 (.028)
dlog(Employment)	To be verified (t.b.v.)	-.096 (.016)	-.057 (.020)

Legend: the results refer to six different panel regressions. Standard errors (s.e.) in parentheses.

Table 2: The negative impact as evidence of price rigidity: a sample splitting analysis

Dependent Variables	Alternative measures of productivity changes as Regressors					
	dp1 (Olley-Pakes)		dp2 (Basu-Kimball)		dp3 (Solow residual)	
	Stickier	More flex	Stickier	More flex	Stickier	More flex
dlog(Total hours)	t.b.v.	t.b.v.	-.248 (.035)	.021 (.052)	-.376 (.042)	-.213 (.060)
dlog(Employment)	t.b.v.	t.b.v.	-.212 (.025)	-.068 (.037)	-.132 (.029)	-.017 (.044)

Legend: the results refer to twelve different panel regressions. “Stickier” and “more flex” refer to subsamples where the splitting criterion is based on the frequency of price revisions.

Table 3: The negative impact as evidence of price rigidity: a new splitting criterion

Dependent Variables	Alternative measures of productivity changes as Regressors					
	dp1 (Olley-Pakes)		dp2 (Basu-Kimball)		dp3 (Solow residual)	
	Stickier	More flex	Stickier	More flex	Stickier	More flex
dlog(Total hours)	t.b.v.	t.b.v.	-.179 (.037)	-.003 (.041)	-.320 (.037)	-.221 (.042)
dlog(Employment)	t.b.v.	t.b.v.	-.127 (.026)	-.079 (.030)	-.068 (.026)	-.043 (.030)

Legend: the results refer to twelve different panel regressions. “Stickier” and “more flex” refer to subsamples where the splitting criterion is based on the size of price revisions.

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