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A time series analysis of labor productivity. Italy *versus* the European countries and the U.S.☆

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ABSTRACT

This paper aims at analyzing labor productivity per hour worked in the manufacturing industries of four industrialized countries, Germany, France, Italy and the U.S., between 1950 and 2010. It uses the common trends - common cycles approach to decompose series into trends and cycles. We find that the four national manufacturing sectors share three common trends and one common cycle. Further, we show that trend and cycle innovations have a negative relationship that supports the 'opportunity cost' approach to productivity growth. Finally, trend innovations are generally larger that cycle innovations, with the exception of Italy.

1. Introduction

This paper aims at analyzing labor productivity per hour worked in the manufacturing industries of four industrialized countries, Germany, France, Italy and the U.S., between 1950 and 2010. It uses a time series approach by which it is possible to calculate the secular-nonstationary (trend) and cyclical-stationary components for each time series without imposing restrictive assumptions on how transitory and permanent shocks affect selected variables. We are interested in studying trend and cyclical components of labor productivity in the four countries because, by measuring the weights of innovations and understanding their relationship, we will be able to uncover the determinants of their growth performances. In this paper we are not concerned about what generates business cycles.

We focus on manufacturing because export-led models of economic growth suggest that the evolution of labor productivity in this sector is crucial to understand the active forces that affect the short- and long-run economic performance of national economies. Indeed, the evolution of manufacturing labor productivity and its fluctuations are central in understanding output variations over time. In addition, manufacturing labor productivity is quite volatile, but is often procyclical and closely related to the impulses or propagation mechanisms underlying business cycles (Basu and Fernald, 2001). Finally, manufacturing productivity shows a closer relationship with the concept of technology shocks than GDP per capita (Calcagnini, 1995).

The traditional way of approaching economic growth and fluctuations is to separate trends from cycles, because the latter are thought of as a time-series transitory component. Several methods have been used to define trends. The simplest is an exponential growth path that best fits the historical data. In the literature a variety of filtering methods have been proposed to separate trends from cycles. The standard procedure is to employ one of the following different detrending methods to extract the cycle component from the historical data: time series differencing, moving average techniques, and several types of filters: Hodrick and Prescott (1997), Baxter and King (1999), Kalman (1960), Harvey (1989) and Christiano and Fitzgerald (2003).

Unfortunately, different filtering methods often lead to different conclusions about the characteristics and the dimension of the two time-series components (Canova, 1998). In the case of labor productivity, this indeterminacy generates two main empirical problems: 1) it is difficult to quantify temporary productivity variations and, therefore, results regarding business cycles are sometimes implausible (Erber and Fritsche, 2005; Gordon, 2003); and 2) computing a robust measure of the extent to which business cycles move together across economies is not an easy task so that, the question of business cycle synchronization still remains an open question (Artis, 2003; Artis and Zhang, 1997; Bayoumi and Eichengreen, 1993; Calcagnini and Travaglini, 1998; Darvas and Szapàry, 2004; Giannone et al., 2008; Inklaar and De Haan, 2001; Mitchell and Massmann, 2004).

To overcome these problems, we employ the multivariate procedure developed by Vahid and Engle (1993), Engle and Issler (1995), Issler and Vahid (2001) and Kozicki (1993), known as the common trends–common cycles approach. This methodology has the appealing feature that, in the special case where the number of common trends and common cycles adds up to the number of time series, trend and cyclical components can be calculated as simple linear combinations of the data. Further, in this special case we are able to identify trend and cycle components without imposing *a priori* conditions on the relationships

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Table 1
Labor productivity growth rates in manufacturing. (Means of annual percentage growth rates of output per hour: 2002 = 100).
(Source: Our calculations on the US Bureau of Labor Statistics data.)

	1950–2010	1950–1980	1981–1990	1991–2000	2001–2010
USA	3.37	2.53	3.32	4.24	5.05
Germany	4.10	5.69	2.47	3.24	1.81
France	3.88	4.54	3.34	3.83	2.51
Italy	3.98	6.07	3.19	2.56	−0.05

Table 3
Johansen tests for cointegration: 1951–2010. (r = number of cointegrating relationships).

Null	Log likelihood	Eigenvalue	Trace statistic	5% critical value
r= 0	539.7	.	53.27	47.21
r< =1	552.2	0.342	28.15	29.68
r< =2	559.6	0.218	13.43	15.41
r< =3	564.7	0.158	3.14	3.76
r< =4	566.3	0.051	.	.

existing among the different type of shocks in the economy, as in the case of other time series decomposition analyses (*i.e.* Blanchard and Quah, 1989).

In this paper we focus on the annual manufacturing labor productivity in three major European economies and the U.S. from 1950 to 2010. The choice of employing annual data is motivated by the fact that they are less affected by measurement error than quarterly or monthly data (Artis and Zhang, 1997; Camacho et al., 2006; Inklaar and De Haan, 2001; Mitchell and Massmann, 2004), and are available for a relatively long period of time. Further, by using labor productivity per hour worked we try to account for variations in labor utilization which are a major reason for the procyclicality of measured productivity. Indeed, true input services are more cyclical than measured input services. For instance, this is the case in the presence of labor hoarding. As a result, productivity is spuriously cyclical (Sgherri, 2005; Solow, 1957). Finally, choosing the U.S., Germany, France and Italy, where the degree of economic development is similar, should give us some advantages in terms of this countries' stochastic properties. We expect that these four countries share a larger number of stochastic trends and cycles than in the case of a larger 'club' that includes countries with different levels of economic development.

Common trends are identified in the context of cointegrating relationships. Evidence of a single common trend would suggest that productivity time series have structural characteristics of such similarity across economies that the (log) level of productivity per hour worked converges in the long run. Common cycles, on the other hand, are short-run relationships linking stationary series. If the four economic cycles depend upon the same shocks, a single common cycle can be identified as evidence of business cycle synchronization.

We obtain four main results. *First*, we find only one cointegrating relationship among the labor productivity time series of the four countries. This result implies that the four time series share three stochastic trends which, in turn, implies the absence of convergence of national labor productivity levels. In other words, the existence of one cointegrating vector means that national manufacturing industries are structurally different and affected by alternative shocks (or that the same shock produces different results in each country because of the economic and institutional environment in which they occur). *Second*, we find that the four time series share a single business cycle. This result implies that the short-run component of labor productivity depends upon the same shock(s) in all countries. Interestingly, the two previous results provide a unique dynamic structure of shocks because the sum of stochastic trends (three) and common cycles (one) is equal to the number of time series (four). Therefore, there is only one trend-cycle decomposition of manufacturing labor productivity in each country. *Third*, our analysis shows that the correlation coefficient between trend and cycle innovations is negative and statistically significant in all countries, but Italy. *Finally*, we find that trend innovations are generally larger than cycle innovations, with the only exception being Italy. Trend innovations are relatively larger in France and the U.S. than in Germany.

The negative relationship between trend and cycle innovations supports the 'opportunity cost' approach to productivity growth (Saint-Paul, 1993). According to this theory, the intertemporal substitution of productivity-improving activities along the business cycle predicts that recessions are associated with a higher pace of productivity-improving activities. We show that the U.S. and France are the economies that 'benefit' more from short-run negative innovations because, for a given negative shock, their manufacturing industries react by reallocating resources and obtaining the largest improvement on long-run labor productivity. Differently from the other three countries, the size of Italian cycle innovations is on average larger than trend innovations, but there is no statistically significant relation between the two types of shock.[1] In addition, the number and mean size of these shocks in Italy are smaller than the ones of the other countries. For instance, during the last decade, labor productivity in Italian manufacturing experienced only 1 positive trend innovation, while there were 5 in the case of the U.S., 6 in France and 8 in Germany.

The paper is organized as follows. The next section describes the data and results from the common trends common cycles approach. Section three deals with the broader interpretation of results with remarks that are only conjecturable from the common trends common cycles analysis. Then, section four discusses the main implications for economic policies. The last section concludes.

2. The empirical analysis

2.1. Data

Our analysis makes use of labor productivity per-hour-worked time series calculated by the Bureau of Labor Statistics (BLS) for international comparison for the period 1950–2010.[2] All time series are annual indexes with base 2002 = 100.

Labor productivity is defined as real output per hour worked. BLS constructs trends of manufacturing labor productivity from two basic aggregate measures: output and total labor hours. These measures relate to total manufacturing as defined by the International Standard Industrial Classification (ISIC). However, the measures for France include parts of mining. Data for the U.S. are in accordance with the North American Industry Classification System (NAICS).

Most measures are prepared according to the United Nations System of National Accounts 1993 (SNA 93) for the most recent years. For earlier years, data were compiled from other systems of national accounts. To obtain historical time series, BLS may link together data series which were compiled according to different accounting systems by national statistical offices.

For recent years, the output measures are real value added in manufacturing, based on national accounts. Most countries now estimate

Table 2
Modified Dickey–Fuller (DF-GLS) test: 1952–2010. (Null: time series is nonstationary).

	Test statistic	5% critical value	Max lag
USA	−1.829	−2.205	1
Germany	−1.228	−2.191	2
France	−1.258	−2.205	1
Italy	−0.953	−2.191	2

[1] The correlation coefficient between trend and cycle innovations has the same negative sign as in the other three economies only when cycle innovations are entered at lag 2.

[2] Time series are available at http://www.bls.gov/news.release/prod4.toc.htm.