Long-Run Growth and Income Distribution: Evidence for Italy and the US

Claudio Morana
Università del Piemonte Orientale
November 2002

Abstract

In this paper we investigate the long-run growth process in Italy and the US over the period 1920-2001, using a common trends model. Coherent with the neoclassical growth model, we find that long-run economic growth can be explained by two permanent shocks, namely a technological shock and a labour supply shock. Interestingly, technological progress has an initial negative impact on the wage share, and a successive positive, but transitory impact on income equality, pointing to a cycle in income distribution. On the other hand, the labour supply shock has a transitory and positive impact on the wage share for Italy, and a permanent and negative impact on the wage share for the US, possibly reflecting different labour market institutional characteristics. Hence, fluctuations in the distribution of income should be expected as a consequence of economic growth.

*J.E.L. classification:* C32, O11.

*Keywords:* Markov switching, common trends, economic growth.

*Address for correspondence:* Claudio Morana, Università del Piemonte Orientale, Facoltà di Economia, Dipartimento di Scienze Economiche e Metodi Quantitativi, Via Perrone 18, 28100, Novara, Italy. E-mail: morana@eco.unipmn.it. The author is grateful to R. Golinelli and G. Siciliano for providing part of
the data employed in this study. Many thanks to R. Golinelli also for advices concerning the construction of the data and to A. Beltratti, G. Bertola, and seminar participants at the University of Piemonte Orientale for comments. The author is also grateful to an anonymous referee for useful comments. The paper was written as a contribution to the project financed by Piedmont Region “la ricerca economica e sociale a supporto delle politiche locali di sviluppo” (Ricerca d’Eccellenza, responsabile: Prof.ssa L.Baici).

1. Introduction

Since the mid eighties, the theory of growth has experienced a noteworthy revival. New developments in the theory of growth were called for in order to tackle the apparent empirical failure of the neoclassical growth model (Solow 1956; Cass, 1965; Koopmans, 1965) to account for the divergent growth paths experienced by both industrialised and developing countries, leading to the modelling of endogenous forces which may explain long-run economic growth and the disparity in per capita income and growth rates (see Aghion - Howitt, 1998 for a survey). The empirical evidence in favour of a modified version of the Solow model, augmented for human capital, and the conditional convergence hypothesis (Barro, 1991; Mankiw - Romer - Weill, 1992; see also Sala-i-Martin, 1996, for a summary of the results), has been also questioned on the basis of the soundness of the econometric methodologies employed (Lee - Pesaran - Smith, 1995; Quah, 1996), with alternative approaches pointing to the emergence of club convergence in the distribution of world wide per capita income since the 1980s (Bianchi, 1995). However, more recently, Bernanke - Gurkainak (2001) have been unable to reject the hypothesis of exogenous growth for OECD countries and a restricted sample composed of the Western hemisphere industrialised countries only, although they find cross sectional correlation of the Solow residual with the saving rate, using averages by country to account for out of steady state dynamics.1 Evidence in support of a stochastic version of the Solow model and against a stochastic AK model have

1Whether this latter finding points to rejection of the exogenous growth model is questionable. Firstly, it is well known in the literature that the Solow residual is not a good proxy for technological progress. Secondly, as also the authors note, the positive correlation is what one would predict, on the basis of the Ramsey-Cass-Koopmans version of the model, where the saving rate depends on the rate of technical progress. In addition, also the Solow (1956) model predicts a positive correlation of the saving rate and the rate of growth of per capita output over the transition to the steady state. Finally, it is not clear whether averaging out of steady state dynamics yields a good proxy for steady state dynamics.
been also provided by Binder - Pesaran (1999), coherent with the seminal results of King - Plosser - Stock - Watson (1991) and Neusser (1991), supporting the stochastic neoclassical model and its prediction of balanced growth. Implicit support for the neoclassical growth model can also be found in the work of Gordon (2000a,b), namely in the association of productivity advances with the introduction of some key inventions, which brought deep improvements in the quality of life, and originated independently of economic forces. Moreover, an interesting prediction of endogenous growth models that rely on capital accumulation to explain the process of growth is the negative relationship between the rate of growth and the wage share, pointing to an important linkage between income distribution and growth. Recent evidence on the similarity of the wage shares in both developing and industrialised countries (Bernanke - Gurkainak, 2001) may cast some doubts on the validity of this prediction, since the observed cross sectional dispersion of growth rates may not be explained by the dispersion in the wage shares. This finding provides implicit support for models where growth is unrelated to capital accumulation, as the neoclassical growth model. In fact, in the framework of the neoclassical growth model income distribution does not play any role in determining the rate of growth of the economy, since the latter is explained by technology and labour supply growth. Moreover, economic growth does not affect factor shares in the long-run, since the latter are constant or stationary. However, empirically the interaction between income distribution and growth may be of interest along the transition path, when the neoclassical properties of the model may not hold exactly. In particular, growth shocks may induce fluctuations in income distribution as well. Therefore, also in the framework of the neoclassical model, which may be appropriate to describe the long-run behaviour of the econ-

\[\text{Gordon (2000a) identifies four major groups of inventions in the late nineteenth and early twentieth century: electric light and motors, internal combustion engines, petroleum and processes which rearrange molecules (petrochemicals, pharmaceuticals) and communications innovations. Interestingly, according to Gordon (2000b), the invention of the Internet in the mid-1990s was a much less important invention, unlikely to produce the productivity advances expected by many authors. Even the invention of the computer would have already exercised its benefits, due to its strong diminishing returns, determined by the fixed amount of time and brainpower of users. These considerations have lead Gordon to recast the question on the causes of the productivity slowdown since the 1970s as a question of why productivity grew so fast over the period 1891-1972. The above mentioned inventions are his answer to the question. A similar reasoning holds for Italy as well. For instance, Giannetti (1993) suggests that, since 1860, technical change in Italy may be related to previous scientific discoveries in natural sciences. See also Rossi - Toniolo (1993) for an analysis of the productivity dynamics in Italy over the period 1893-1990.}\]
omy, the analysis of the linkages between growth and income distribution may be of empirical interest, particularly when the transition to the steady state is a lengthy process. It should be remarked that output, employment and real wage shocks are primitive shocks relative to wage share shocks by construction, since the wage share is measured by the ratio of the real wage and output per worker. Hence, shocks which affect these latter variables will also affect the wage share, unless they are exactly offsetting. Hence, it does not appear to be appropriate to start from the assumption of an income distribution shock and investigate its causal impact on economic development. Rather, fluctuations in income distribution should be expected as a consequence of economic growth shocks. The fact that a change in income distribution may affect economic growth cannot be excluded, but the role of income distribution should then be seen as a transmission mechanism, rather than an impulse mechanism.

In this paper therefore we employ the neoclassical growth model to assess empirically the interactions between growth and income distribution along the transition to the steady state for Italy and the US. This is accomplished in the framework of a common trends model, which is a natural to model the exogenous nature of the growth engine. Our work also contributes to the literature by providing time series evidence on the process of long-run growth over a long time span, to complement the available evidence based on panel data, where the time dimension is small. An important difference between the two countries analysed concerns the institutional characteristics of the labour market, more deregulated in the US and subject to important frictions in Italy. Since the labour market plays a key role in explaining how the growth process may affect income distribution, we believe the comparison to be of interest.

To anticipate the main results of the study, we find evidence in favour of stochastic balanced growth and of two engines of growth, which, in accordance with the neoclassical growth model, can be interpreted as labour supply and technology. We also find evidence of cyclical dynamics in the wage share during the transition path. Technological advances depress initially the wage share, but lead to an increase in labour rewards in the longer run. The impact is transitory for Italy and permanent for the US. On the other hand, labour supply shocks have an expansionary, but transitory impact on the wage share for Italy, and a permanent negative impact on the wage share for the US, possibly reflecting different labour market characteristics in the two countries. In fact, the long-run labour demand equations in the two countries conform to different paradigms, with long-run homogeneity between per capita output and the real wage holding
for Italy only. This implies a unitary elasticity of employment relative to the real wage and output, and that the technological shock exercises the same long-run impact on both variables, leaving the wage share unaffected in the long-run. Hence, fluctuations in income distribution should be expected in the short-run as a consequence of the process of economic growth. Interestingly, for the US the negative correlation between long-run growth and the wage share emerges as a consequence of the growth of the supply of labour in a flexible labour market. But the relationship between income distribution and growth is not univocal, since productivity shocks influence positively both income equality and growth. On the other hand, for Italy the relation between income equality and growth is positive in the medium/long term, albeit zero asymptotically.

The paper is organised as follows. In section two we discuss the theoretical linkages between income distribution and economic growth. In section three we present the theoretical framework and in section four the econometric methodology. In section five we present the empirical results. Finally, in section six we conclude.

2. Long run growth and income distribution

The origin of the literature on the relationship between long-run growth and income distribution can be traced back to the work of Kaldor (1956). Recently, many authors have contributed to the literature, including Aghion - Caroli - Garcia-Penalosa (1999), Bertola (1993a, 1993b, 1996), Alesina - Rodrik (1994), Perotti (1993), Persson - Tabellini (1992, 1994), Ben-Habib - Rustichini (1991), Fay (1993), Saint-Paul - Verdier (1993), Lee - Romer (1998). In these papers it is assumed that income inequality may affect long-run growth by influencing the accumulation of both physical and human capital.

Following Bertola (1998), the linkage between growth and distribution, as originally put forward by Kaldor (1956), can be expressed by the following equation

$$\theta = 1 + s^p (1 - \gamma) \frac{Y}{K},$$

where $\theta$ is the gross rate of balanced growth of the economy determined by exogenous labour augmenting technical change ($A$), i.e. $\theta = A_t / A_{t-1} = Y_t / Y_{t-1} = K_t / K_{t-1} = C_t / C_{t-1}$, $s^p$ is the rate of saving of the capitalists, $\gamma$ is the share of income paid to the workers, and $Y/K$ is the output-capital ratio. Assuming that the output-capital ratio is exogenous as well, and taking as given the saving rate
of the capitalists, there exists only one value of the wage share which is compatible with the remaining parameters of the models. In the model therefore income distribution, along the balanced growth path, is determined by the saving ratio of the capitalists. Interpreting the relationship as pointing to a causal linkage between distribution and growth, then it is possible to conclude that a lower wage share implies faster economic growth, through faster capital accumulation

\[ \Delta K = s^p RK = s^p(1 - \gamma)Y, \]

where \( R \) is the return of one unit of capital.

The implication of the standard neoclassical model concerning the role of capital accumulation in long-run growth are very different, and can be easily seen from the growth equation below

\[ \frac{\Delta Y}{Y} \sim F_K \frac{\Delta K}{Y} + F_L \frac{L}{Y} \Delta L, \]

where \( F_i \) \( i = K, L \) is the marginal productivity of factor \( i \), \( \frac{\Delta K}{Y} \) is the saving rate, \( F_L \frac{L}{Y} \) is the wage share, and \( L \) is labour in efficiency unit. Since the marginal productivity of capital decreases as the stock of capital increases (\( \lim_{K \to \infty} F_K = 0 \)), asymptotically the contribution of saving and capital accumulation to output growth becomes negligible, and output grows at the exogenous rate determined by population growth and technical change.

A similar result to that obtained by Kaldor (1956) can be derived in endogenous balanced growth models with optimal saving decisions as Bertola (1993)

\[ \theta = \frac{1 + R}{1 + \rho} = \frac{1 + (1 - \gamma)\frac{Y}{K}}{1 + \rho}, \]

where \( \rho \) is the intertemporal rate of discount, so that faster growth is associated with a higher rate of return to capital or a lower wage share. In this model endogenous growth arises from capital accumulation under the assumption of constant returns to capital, so that the marginal productivity of capital is constant and does not fall to zero asymptotically. An implicit assumption of the model is the negligible contribution of labour to output production. If this latter feature does not hold, then the production function shows increasing returns to scale and distributional issues are complicated by the fact that social and private remunerations of the factors of production do not coincide. Also in this latter case distribution is
still relevant for growth, but additional factors as policies, institutions and politics play an important role.

Although the above theoretical discussion concerns the functional distribution of income, the implication for the personal distribution of income may be easily established by assuming that the left tail of the personal distribution of income is characterised by individual with low capital to labour ratio, while the opposite holds for the right tail. Under this assumption an increase in the wage share would imply a reduction in income inequality.

Recent contributions to the literature tend to suggest that inequality is harmful to growth. However, as noted by Barro (1999), this conclusion is at least ambiguous, since these theories tend to show offsetting forces as well. Three main channels through which inequality could affect the accumulation of both physical and human capital are identified. Firstly, in a democratic one-man, one-vote system, if the median voter is capital-poor relative to the economy, fiscal policy will tend to penalise the accumulated factor. With saving and growth rates positively related to accumulated factor rewards, the economic policy voted will exercise a negative impact on economic development. This effect, however, will work only if the distribution of political power is uniform and the allocation of economic power is unequal. Secondly, in the presence of capital markets imperfections, a more equal distribution of income should promote growth by allowing a larger number of individuals to invest in both human and physical capital. However, if investment requires setup costs that are large relative to median income, a more equal distribution of wealth could dampen economic growth. Moreover, since capital markets tend to improve with economic development, this channel should be more important for poor economies than for richer ones. Finally, income inequality may trigger socio-political instability. This in turn can disrupt market activities directly and generate a more uncertain environment which discourages investment. The empirical evidence on the relationship between inequality and growth is also mixed. For instance, Perotti (1994, 1996), Persson - Tabellini (1992, 1994) and Alesina - Perotti (1996) find a negative relationship. On the contrary, Li - Zou (1998) and Forbes (2000) find a positive relationship\(^3\), while Barro (1999) finds a negative relationship for poor countries and a positive relationship for rich countries. Finally, Panizza (2002) has documented the lack of any robust relationship between income distribution and growth for US states. Recently, Bernanke

\(^3\)Forbes (2000) explains the finding of a negative relationship between inequality and growth as the result of downward bias imparted to the estimates by the omission of country specific dummies.
- Gurkainak (2001) have provided evidence of similar wage shares for developing and industrialised countries (between 0.6 and 0.8), with no tendency of the labour share to vary with per capita income or the capital labor ratio, and to rise or fall over time. This finding suggests that the functional distribution of income cannot explain the cross sectional dispersion of growth rates, and invalidates endogenous growth models which explain growth through the process of capital accumulation, predicting a negative relationship between the wage share and the growth rate.

However, the fact that the neoclassical growth model is far from being rejected by the empirical evidence does not imply that the analysis of the linkages between income distribution and long-run growth is a meaningless exercise, particularly when the transition to the steady state is a lengthy process, so that most of the observed growth dynamics in actual data may be related to the transition process. This observation motivates the analysis of the relationship between income distribution and long-run growth in the framework of the neoclassical model. In particular, we expect the neoclassical model to describe accurately the long run evolution of the steady state only, allowing the data to reveal the adjustment path to the steady state. However, in this framework the linkage between distribution and growth is not causal, but consequential, since the engines of growth in the neoclassical model (productivity and employment) are primitive shocks relative to wage share shocks. In fact, a primitive wage share shock cannot be theoretically assumed, since the latter can be decomposed in terms of shocks to the composing variables (real wages and per capita output). Starting from a wage share shock and investigating its impact on economic growth does not seem to be appropriate, since a change in the wage share occurs as a consequence of a change in one or both variables underlying its determination. Fluctuations in income distribution, therefore, should be expected as a consequence of economic growth. Obviously, it is likely that changes in income distribution may lead to further consequences on economic activity, but these effects should be understood in terms of a transmission mechanism, rather than as an impulse mechanism.

3. Theoretical framework

The theoretical framework of the analysis is the balanced path solution of the standard neoclassical growth model. The model predicts that two exogenous engines drive the process of growth in the long-run, namely productivity and labour supply growth, and that the key variables in the model, i.e. output, consumption, investment, and the capital stock grow at the same rate, determined by the two
growth engines. The model also predicts that the same variables in per capita term grow at a rate determined by the productivity improvement, while the steady state factor shares are unaffected. When productivity and labour supply follow a stochastic process rather than a deterministic process, the model predicts that the evolution over time of the key variables in level is determined by two common stochastic trends, and that the great ratios, i.e. consumption-income, investment-income, capital-income, and the wage and capital shares are stationary processes. This implies the existence of cointegration among the variables in the model and the stationarity of the real interest rate.

The evolution along the balanced path of the variables in levels is driven by two non stationary stochastic processes, namely an exogenous technology variable

\[ a_t = \gamma_1 \theta_t \]  
\[ \theta_t = \mu_\theta + \theta_{t-1} + \nu_{\theta,t}, \]  
\[ \nu_{\theta,t} \sim i.i.d(0, \sigma^2_{\nu_\theta}), \]  

and an exogenous labour supply variable

\[ e^s_t = \gamma_2 \xi_t, \]  
\[ \xi_t = \mu_\xi + \xi_{t-1} + \nu_{\xi,t}, \]  
\[ \nu_{\xi,t} \sim i.i.d(0, \sigma^2_{\nu_\xi}). \]  

By writing the deviation from the log steady state solution of the model as

\[ y_t - a_t - e^s_t = y^s + \varepsilon_{y,t} \]  
\[ c_t - a_t - e^s_t = c^s + \varepsilon_{c,t} \]  
\[ i_t - a_t - e^s_t = i^s + \varepsilon_{i,t} \]  
\[ k_t - a_t - e^s_t = k^s + \varepsilon_{k,t}, \]  

where "*" denotes the steady state per capita value of the variables in logs expressed in efficiency units (output (y), consumption (c), investment (i), capital
stock \((k)\), \(\varepsilon_{j,t} = y, c, i, k\) are i.i.d. disturbance processes, the following equations for the variables in level can be obtained

\[
y_t = y^* + \gamma_1 \theta_t + \gamma_2 \xi_t + \varepsilon_{y,t},
\]
\[
c_t = c^* + \gamma_1 \theta_t + \gamma_2 \xi_t + \varepsilon_{c,t},
\]
\[
i_t = i^* + \gamma_1 \theta_t + \gamma_2 \xi_t + \varepsilon_{i,t},
\]
\[
k_t = k^* + \gamma_1 \theta_t + \gamma_2 \xi_t + \varepsilon_{k,t}.
\] (3.6)

It is immediate to verify that the model predicts that the great ratios are stationary processes

\[
c_t - y_t = c^* - y^* + \varepsilon_{c,t} - \varepsilon_{y,t}
\]
\[
i_t - y_t = i^* - y^* + \varepsilon_{i,t} - \varepsilon_{y,t}
\]
\[
k_t - y_t = k^* - y^* + \varepsilon_{k,t} - \varepsilon_{y,t},
\] (3.7)
yielding three plausible candidate long-run relationships.

A fourth candidate long-run relationship is provided by the labour demand equation.

\[
e_l^d = \lambda y_t - \eta w_t + \varepsilon_{e,t},
\] (3.8)
\[
\varepsilon_{e,t} \sim i.i.d(0, \sigma_{e}^2),
\] (3.9)

where \(w_t\) is the log real wage, and \(\lambda\) and \(\eta\) are the output and wage elasticities. A competitive labour market would imply \(e_l^d = e_l^*,\) and \(\lambda = \eta = 1,\) i.e. a stationary wage share

\[
w_t + e_t - y_t = \varepsilon_{e,t},
\] (3.10)
or a homogeneous relationship between the real wage and productivity \((a_t)\)

\[
w_t = y^* + \gamma_1 \theta_t + \varepsilon_{y,t} + \varepsilon_{e,t}.
\] (3.11)
Finally, a fifth cointegrating relationship is provided by the stationary real interest rate

\[ r_t = \mu_r + \varepsilon_r. \]

Given the stationarity of the capital-output ratio, this latter relationship implies the stationarity of the capital share \( r_t K_t / Y_t \).

Given the seven variables in the model (consumption, investment, the stock of capital, output, employment, the real interest rate and the real wage) and the two common trends (productivity and labour supply), the fifth above mentioned stationary relationships are necessary and sufficient to close the system.

From Tobin’s q theory it is possible to postulate a relationship between the market value of the stock of capital \( (f_t) \) and its replacement cost \( (k_t) \). We have in fact

\[ q_t = f_t - k_t, \]  
\[ (3.12) \]

that is

\[ f_t = q + k_t + \varepsilon_{q,t}, \]  
\[ (3.13) \]

where \( q_t = q + \varepsilon_{q,t} \), which then enables to rewrite the stationary capital-output ratio in terms of the stock market index \( f_t \), yielding

\[ f_t - y_t = q + k^* - y^* + \varepsilon_{k,t} - \varepsilon_{y,t} + \varepsilon_{q,t}, \]  
\[ (3.14) \]

and

\[ f_t = q + k^* + \gamma_1 \theta_t + \gamma_2 \xi_t + \varepsilon_{k,t} + \varepsilon_{q,t}. \]  
\[ (3.15) \]

According to Hall (2001), the capital stock measured by the value of equities is a comprehensive aggregate, reflecting both tangible and intangible assets firms employ in production. It can be argued that this measure of capital is closer to the aggregate capital stock postulated in modern growth theory, reflecting physical capital, knowledge and human capital. The modelling framework we follow therefore is closer in spirit to Mankiw - Romer - Weil (1992), rather than to the original model of Solow (1956).

Neglecting constants, the long-run evolution of the variables in per capita terms can then be summarised by the following system of equations.
which shows how per capita income, consumption, investment, the market value of the stock of capital, and the real wage are determined by the productivity trend, while the long-run dynamics of employment are determined by labour supply conditions. Finally, the real interest rate is unaffected by the two growth engines in the long-run.

In the framework of the neoclassical model of growth there is no relationship between growth and income distribution in the steady state, since the wage share is stationary. However, from an empirical point of view, productivity and labour supply shocks may affect the wage share during the transition towards the steady state. The plausibility that convergence towards the balanced growth path is a lengthy process makes the empirical analysis of the transitional dynamics and of the effects of the permanent shocks on income distribution of economic relevance, justifying the use of the neoclassical model of growth to study the interactions between growth and income distribution.

4. Econometric methodology

4.1. Estimation of the MS-VECM model

Following Krolzig (1997), a Markov-switching vector equilibrium correction model (MS-VECM) allowing for state dependence of both the intercept and the error variance-covariance matrix can be written as:

\[
\Pi^*(L) \Delta x_t = \nu(s_t) + \Pi x_{t-1} + \varepsilon_t
\]

where \( x_t \) is a vector of \( n \) I(1) cointegrated variables of interest subject to regime shift, \( \varepsilon_t \sim NID(0, \Sigma(s_t)) \), \( \Pi(L) = I_n - \sum_{i=1}^p \Pi_i L^i \), \( \Pi = -I(1), \) \( \Pi^*(L) = I_n - \sum_{i=1}^{p-1} \Pi_i^* L^i \) and \( \Pi_i^* = -\sum_{j=i+1}^p \Pi_j \) \((i = 1, \ldots, p-1)\).

The regime-generating process is modelled according to a discrete-state homogeneous Markov-chain defined by the transition probabilities \( p_{ij} = \Pr(s_t = j | s_{t-1} = i) \),
with $\sum_{j=1}^{2} p_{ij} = 1 \forall i, j \in \{1, 2\}$.

If there are $0 < r < n$ cointegration relationships among the variables, $\Pi(1)$ is of reduced rank $r$ and can be expressed as the product of two $(n \times r)$ matrices: $\Pi(1) = \alpha\beta'$, where $\beta$ contains the cointegrating vectors, such that $\beta'x_t$ are stationary linear combinations of the $I(1)$ variables, and $\alpha$ is the matrix of factor loadings.

The model is estimated in two stages. In the first stage the long-run equilibrium relationships are estimated by means of the Johansen (1988) approach ignoring the presence of different regimes. In the second stage the estimated error correction terms are included as exogenous regressors in the specification, and the MS-VECM is estimated via the Expectation-Maximization (EM) algorithm. See Krolzig (1997) for further details.

4.2. Estimation of the common trends model

On the basis of the estimated smoothed probabilities $\Pr(s_t = j \mid s_{t-1} = i|X_T)$ a partition of the sample observations between the non-shock and shock regimes is then obtained. The Wold vector moving average representation (VMA) of the cointegrated system for the non-shock regime ($s_t = 2$) can be obtained following Mellander - Vredin - Warne (1992) and Warne (1993), provided that restrictions are imposed on the restricted vector autoregressive representation (RVAR).

4.2.1. RVAR and common trends representations

The RVAR representation can be written as

$$B(L)Y_t = \theta + \eta_t$$

where $B(L) = T[I^* (L) T^{-1}D(L) + \alpha^* L]$, $Y_t = D_\perp (L) T x_t$, $T = [\beta' \beta]'$, $\alpha^* = [0 \alpha]'$ and $D(L)$ and $D_\perp (L)$ are polynomial matrices defined by

$$D(L) = \begin{bmatrix} I_k & 0 \\ 0 & (1-L)I_r \end{bmatrix}, \quad D_\perp (L) = \begin{bmatrix} (1-L)I_k & 0 \\ 0 & I_r \end{bmatrix}.$$  

When instability is modelled in terms of shifting intercept vector and error variance covariance matrix, these restrictions can be easily imposed by remembering the relationship linking the VECM and RVAR representations, that is

$$\theta = T\nu$$
\[ \eta_t = T \varepsilon_t. \]

so that

\[ \theta = T \nu(2) \]

\[ \Omega = T \Sigma (2) T', \]

where \( \Omega = E[\eta_t \eta'_t] \).

The RVAR representation has the property that all the variables are stationary, either because they are expressed in first differences or as stationary linear relations. Then, the RVAR can be inverted to obtain the common trends representation of Stock - Watson (1988), which, in structural form, can be written as

\[ x_t = x_0 + \mu t + \Gamma (1) \sum_{j=0}^{t-1} \varphi_{t-j} + \Gamma^* (L) \varphi_t \]

\[ = x_0 + \mu t + \Gamma_g \sum_{j=0}^{t-1} \psi_{t-j} + \Gamma^* (L) \varphi_t, \quad (4.3) \]

where \( \varphi_t \equiv \begin{bmatrix} \psi_t & \upsilon_t \end{bmatrix}' \sim I.I.D. (0, I_n) \), with \( \psi_t \) and \( \upsilon_t \) subvectors of structural shocks of \( k \) and \( r \) elements respectively, \( \varepsilon_t = \Gamma_0 \varphi_t \), and \( \Gamma (1) = \sum_{j=0}^{\infty} \Gamma_j, \Gamma^* (L) = \sum_{j=0}^{\infty} \Gamma_j^* L^j, \Gamma_j^* = - \sum_{i=j+1}^{\infty} \Gamma_i \), where \( \Gamma_i \) are matrices of parameters in the structural Wold vector moving average (VMA) representation. The existence of \( r \) cointegrating vectors implies that the long-run matrix \( \Gamma (1) \) has rank \( n - r \equiv k \) and \( \beta' \Gamma (1) = 0 \).

In order to identify the elements of \( \psi_t \) as the permanent shocks and the elements of \( \upsilon_t \) as transitory disturbances, only the disturbances in \( \psi_t \) should be allowed to have long-run effects on (at least some of) the variables in \( x_t \). Hence, \( \Gamma (1) = \begin{bmatrix} \Gamma_g & 0 \end{bmatrix}, \) being \( \Gamma_g \) a submatrix of dimension \( n \times k \).

**Identification of the shocks** To identify the common trends model it is necessary to find a matrix \( \Gamma_0 \), such that it can be uniquely determined from the parameters of the VECM model, where the variance covariance matrix of
\[ \Gamma_0^{-1} \varepsilon_t = \varphi_t \] is diagonal with non-zero entries, and the long-run impact matrix is \[ \Gamma(1) = \begin{bmatrix} \Gamma_g & 0 \end{bmatrix} \].

By rewriting the mapping from the reduced form disturbances to the structural disturbances as
\[ \Gamma_0^{-1} \varepsilon_t = \varphi_t \Leftrightarrow \begin{bmatrix} G \\ H \end{bmatrix} \varepsilon_t = \begin{bmatrix} \psi_t \\ \nu_t \end{bmatrix}, \]
it can be noticed that through the \((k \times n)\) matrix \(G\) the reduced form disturbances are mapped into permanent disturbances, and through the \((r \times n)\) matrix \(H\) the reduced form disturbances are mapped into transitory disturbances.

Following Warne (1993), the matrix \(G\) can be estimated as
\[ G = (\Gamma'_g \Gamma_g)^{-1} \Gamma'_g C(1), \quad (4.4) \]
where \(C(1)\) is the long-run impact matrix in the reduced form Wold VMA representation.

To estimate the \((n \times k)\) matrix \(\Gamma_g\), we need (at least) \(nk\) restrictions on its elements. Cointegration implies
\[ \beta' \Gamma_g = 0, \quad (4.5) \]
yielding \(kr\) linear restrictions. Additional \(k(k + 1)/2\) restrictions on the elements of \(\Gamma_g\) are provided by assuming \(E(\psi_t \psi'_t) = E(G \Sigma G') = I_k\). That is, \(k(k + 1)/2\) restrictions are given by
\[ C(1) \Sigma C(1)' = \Gamma_g \Gamma_g', \quad (4.6) \]
since \(C(1)\) and \(\Gamma_g\) have reduced rank \(k\). The remaining \(k(k - 1)/2\) restrictions needed for (exact) identification of \(\Gamma_g\) have to be derived from economic theory.

To estimate the \((r \times n)\) matrix \(H\), we need (at least) \(nr\) restrictions on its elements. It can be noticed that from the orthogonality condition \(E [\psi_t \nu'_t] = 0\) we have
\[ E (G \varepsilon_t \varepsilon'_t H') = G \Sigma H' = 0, \quad (4.7) \]
that is
\[ (\Gamma'_g \Gamma_g)^{-1} \Gamma'_g C(1) \Sigma H' = 0. \]
Hence, reminding that \(C(1) \alpha = 0\), a possible solution for \(H\) takes the form
\[ H = Q^{-1} \zeta' \Sigma^{-1}, \quad (4.8) \]
where \(\zeta = \alpha (U \alpha)^{-1}\), \(U\) is a matrix chosen in such a way that \(U \alpha\) is non-singular, and the \((r \times r)\) matrix \(Q\) is such that \(E [\nu_t \nu'_t] = I_r\). In practice the matrix \(Q\) can
be obtained from the Choleski decomposition of \((\zeta'\Sigma^{-1}\zeta)^{-1}\). The estimation of \(H\) requires the imposition of \(r(r-1)/2\) additional restrictions on the \((r \times r)\) matrix \(\zeta\), since the remaining \(kr + r(r+1)/2\) restrictions necessary for exact identification are provided by the orthogonality conditions \(E[\psi_t \nu_t'] = 0\) and \(E[\nu_t \nu_t'] = I_r\).

By noting that \(\Sigma = \Gamma_0 \Sigma_0\), we have that \(\Gamma_0 = (\Gamma_0')^{-1} = \begin{bmatrix} \Sigma \Sigma' & \Sigma H' \end{bmatrix}\). Thus, the contemporaneous impact matrix can be written as

\[
\Gamma_0 = \begin{bmatrix} \Sigma C(1) \Gamma_g (\Gamma_g' \Gamma_g)^{-1} \zeta (Q^{-1})' \end{bmatrix}.
\]

From the moving average representation impulse response functions and forecast error variance decompositions can be calculated with respect to permanent and transitory innovations.

5. Empirical results

The national accounts, employment and wage data for Italy are from Rossi - Sorgato - Toniolo (1990). The data have been updated to 2001 using several sources (ISTAT, OECD). Italian stock market data are from Siciliano (2001). National accounts, employment and wage data for the US are from Liesner (1989). Stock market data are from Shiller (1999). The data have been updated to 2001 using FRED.

5.1. Integration and cointegration properties of the data

As a preliminary step to cointegration analysis, the integration properties of the data have been assessed. In accordance with the theoretical framework, output, consumption, investment and the stock market index have been expressed in per capita terms. Standard ADF tests suggest that all the per capita variables, as well as employment and the real wage, for both countries, are integrated of order one (I(1)). On the other hand, the real interest rate series are integrated of order zero (I(0)).

\footnote{The results of the unit root analysis are available from the author upon request. The empirical analysis has been carried out over the period 1920-2001. The time span selected avoids accounting for outlying behaviour in US data at the beginning of the century and for the the effects of the First World War. Moreover, employment data for Italy are available since 1911 only. Finally, the selected sample appears to be appropriate for the scope of the analysis. As documented by Fabiani - Trento (1999), the starting point of the technology driven growth phase can be set in the 1920s for the US and in the 1940s for Italy. For sample size reasons we have however used a longer sample size also for Italy.}
Information criteria and specification tests have been employed to select the lag length of the VAR model. According to the SC criteria two lags could be selected for Italy and one lag for the US. However, two lags were also selected for the US on the basis of serial correlation tests. Apart from the per capita investment equation for Italy, there is no evidence of residual serial correlation in the data. The results of the cointegration analysis are reported in Table 1. As shown in the Table, there is evidence of four cointegration relationships at the 5% percent level and of five cointegration relationships at the 10% level for both Italy and the US. Also considering the relative size of the eigenvalues, we have concluded in favour of a cointegrating rank equal to five, which is consistent with the predictions of the neoclassical growth model and with previous results of Ardeni (1993) for Italy and King - Plosser - Stock - Watson (1991) for the US. The theoretical model has also implications for the identification of the cointegration space. In fact, since the model predicts the stationarity of the great ratios, the wage share and the real interest rate, all the long-run relationships are of the homogeneous type. The imposed identification structure is rejected by the data at the 1% level for both countries, although the evidence of stationarity of the great ratios is strong. As far as Italy is concerned, the real interest rate, the wage share and the capital-output ratio appears to be valid cointegration relationships. The cointegrating vectors are also numerically very close to homogeneity for the consumption-income ratio and the investment-output ratio, albeit imposing these additional restrictions leads to rejection of the identifying structure. On the other hand, for the US there is evidence of stationarity of the great ratios and the real interest rate, while the wage share appears to be non stationary. The identified cointegrating vector for the US labour market is a long-run labour demand equation, linking the real wage to productivity and employment. By solving the cointegrating vector with respect to employment it is possible to retrieve the output and real wage elasticities. We have

\[ e_t = 0.43y_t - 0.34w_t, \]

pointing to a rigid response of employment to wages. Similar estimates have been obtained by Morana (2002) for the UK using secular data. The unitary response of employment to wages for Italy is therefore surprising, since the Italian labour market is well known for being more regulated than the US labour market. As shown in Table 1, the identification restrictions imposed on the cointegration space

---

5The null of four cointegrating vectors for the US is only marginally non rejected at the 10% level.

6This finding is further discussed in section 5.5.
are not rejected at the 1% level for both countries.

5.2. Instability analysis and short run dynamics

Following Morana (2002) and Bagliano - Morana (1999), a Markov-switching model has been employed to model structural instability in the short-run component of the model. The estimated model allows for two regimes, with switching variance and intercepts. The rationale underlying this modelling strategy is the attempt to account for the main disruptive events which affected the Italian and US economies over the 20th century, namely the two World Wars, the Great Depression, and the oil shocks of the 1970s and the 1980s. A LR linearity test, with p-values computed as in Davies (1987), strongly supports the Markov switching model for both countries (the null of linearity is rejected at the 1% level\(^7\)), while allowing for constant intercept terms leads to a better specified model.\(^8\) The selected model therefore allows for switching variance covariance matrix only, and standard autocorrelation and heteroscedasticity tests carried out on the standardised residuals support the selected model. The results are reported in Table 2 and Table 3, while in Figure 1 the estimated smoothed probabilities are plotted. As is shown in the plot, the first regime captures the periods of major economic instability associated with the two World Wars and the Great Depression. On the other hand, no evidence of instability can be found for the most recent periods associated with the oil shocks. From the plot it is also possible to note the higher instability in US data over the 1930s, coherent with the much larger impact that the Great Depression had on this economy.

As can be noted from the variance-covariance matrix, the growth rates of the variables in the model tend to show a much larger variance in periods of economic instability than in normal times. The high volatility regime is also less persistent and characterised by a shorter duration than the low volatility regime (the average duration is 6 years for the high volatility regime for both countries and 31 years for the low volatility regime in Italy and 19 years for the US). Similar results have been reported by Morana (2002) for the UK economy.

In Table 3 we also report the estimated loading matrix. According to the estimated parameters, none of the variables can be regarded as weakly exogenous.

\(^7\)The LR linearity tests are \(\chi^2_{(30)} = 420.79\) [0.0000] for the US, and \(\chi^2_{(30)} = 347.16\) [0.0000] for Italy.

\(^8\)The value of the likelihood function increases when the restriction of equal intercepts in the two regimes is imposed (753.8 and 770.8 for Italy, and 923.5 and 1015 for the US). In addition, the estimated intercepts are numerically similar in the two regimes and not statistically different.
The reaction of per capita consumption to the consumption-income ratio is negative and statistically significant for both countries. The same result holds for the investment-output ratio and the capital-output ratio, with investment and capital per worker reacting with the right sign for both countries, although the reaction is significant at the 5% level only for the investment-output ratio. Additional evidence in favour of stationary labour demand equations and real interest rates can also be found, with output, employment and wages reacting to the labour demand disequilibrium. The reaction of the real interest rate change to its own lagged value (in levels) is also negative and significant for both countries. These findings are coherent with the results of the cointegration analysis, and provide additional support in favour of the stationarity of the identified long-run relationships.

An economic interpretation of the other loadings does not seem to be straightforward. Probably the most interesting finding concerns the characteristics of the labour market. For both countries employment reacts more strongly than wages, with the reaction being stronger for the US than for Italy. This result is coherent with the view that the labour market is more rigid in Italy than in the US.

5.3. The common trends model

In accordance with the results of cointegration analysis, two common stochastic trends drives the seven variables in the model, namely technology and labour supply. The neoclassical model predicts that the per capita variables and the real wage are driven by the technological trend alone, while the labour supply trend drives employment. Given the structure of the cointegration space, such identifying structure can be attained by imposing a single exclusion restriction on the factor loading matrix of the CT model, so that only the technological trend affects per capita output. On the other hand, the impact of the technological trend on employment has been left unrestricted, to assess empirically whether technical progress, over the time span analysed, has had a long-term impact on employment. The identification of the CT model requires the imposition of ten additional exclusion restrictions on the impact matrix ($\Gamma_0$) in the VMA representation. Since the focus of the study is on the long-run properties of the system and the identification of the permanent shocks is independent of the identification of the transitory shocks, we do not discuss this latter issue further in the paper.

The common trends representation of the variables in levels is then the follow-
\[
\begin{pmatrix}
y - e \\
c - e \\
i - e \\
f - e \\
w \\
e \\
r
\end{pmatrix}_t =
\begin{pmatrix}
y - e \\
c - e \\
i - e \\
f - e \\
w \\
e \\
r
\end{pmatrix}_0 + \begin{pmatrix}
\gamma_{1,1} & 0 \\
\gamma_{2,1} & 0 \\
\gamma_{3,1} & 0 \\
\gamma_{4,1} & 0 \\
\gamma_{5,1} & \gamma_{5,2} \\
\gamma_{6,1} & \gamma_{6,2} \\
0 & 0
\end{pmatrix} \begin{pmatrix}
\tau_\theta \\
\tau_\xi
\end{pmatrix}_t + \Gamma^*(L) \begin{pmatrix}
\psi_\theta \\
\psi_\xi \\
v_1 \\
v_2 \\
v_3 \\
v_4 \\
v_5
\end{pmatrix}_t.
\]

The discrimination between shock and non-shock regimes allows us to analyse the impact of macroeconomic impulses under normal conditions (non-shock regime) in the innovation process, avoiding possible contaminations arising from outlying events. The analysis has been carried out by taking into account the information provided by the instability analysis as described in the methodological section. In particular, restrictions have been imposed on the variance-covariance matrix of the residuals of the RVAR representation, leaving the intercept vector unrestricted. The estimated factor loading matrix \( \Gamma_y \) is reported in Table 4. Standard errors for the impulse response functions have been computed by Monte Carlo simulation, with 1000 replications.

5.4. Impulse response analysis

In Figures 2-6 we report the impulse response functions to the permanent shocks (unitary impulses). In accordance with the theoretical structure, output, consumption, investment and the stock market index are expressed in per capita terms.\(^9\) As shown in Figure 2 output, consumption, investment and the real wage for Italy show a similar reaction to the permanent productivity shock, increasing

\(^9\)To recover the impulse responses for the variables in levels, the response of the per capita variables should be adjusted for the response in employment.
smoothly over time and stabilising within fifty years, with about a 7% increase over the base line. On the other hand, the stock market reaction to the productivity shock is different, with stock prices increasing of 21% within one year, falling steadily thereafter, and stabilising at about 7% over the base line within seventy years. Moreover, the impact on employment of the productivity innovation is already negative at the outset, building up gradually. The asymptotic impact of the shock is equal to -1.5%, pointing to labour saving technical progress over the time span analysed. The evidence is however weak, since the long run impact of the productivity shock on employment is not statistically significant at the 5% level. Finally, the impact on the real interest rate is transitory, but long lived, peaking at +15bp within three years.

A different pattern is shown by the response to the permanent employment shock. As shown in Figure 3, for Italy the data validate the interpretation of the second permanent shock as a labour demand shock, rather than a labour supply shock, since both employment and the real wage increase at the outset. Employment stabilises at 2% over the base line within fifteen years, with the real wage peaking after five years (+1.9%), but falling thereafter, and converging back to the base line within fourteen years. The permanent employment shock has therefore only a transitory impact on real wages. This result should be expected, given the structure of the cointegration space and the identification scheme adopted for the permanent shocks. Moreover, the labour supply shock has an expansionary, but transitory effect on output, consumption and investment, and a negative impact on the stock market, which falls 3% below the base line within three years, to recover back to the base line within twelve years. The permanent employment shock has therefore an intial negative impact on per capita income and consumption, possibly reflecting the lagged response of output and consumption to the shock. Finally, the employment shock has an expansionary impact on the real interest rate, which peaks within five years (+25bp) and fades away within twelve years.

In Figure 4 we plot the response to the productivity shock for the US economy. The responses of per capita output and consumption are similar at the outset (+1%), with consumption remaining stable thereafter, while output falls in the following years, to increase again after six years. Within twelve years the adjust-

---

10By construction per capita variables are not affected by the labour supply shock in the long-run, since levels increase at the rate determined by both productivity and labour supply. Therefore, per capita variables grow at the rate determined by productivity advances only. Then, the long-run response of the variables in levels to the labour supply shock is given by the long-run response of employment to the same shock (2.16%), yielding a 2.16% increase in output, investment, stock market prices and consumption.
ment is accomplished also for this latter variable. Per capita investment follows a different adjustment path, peaking within three years (+7%), to fall thereafter (-2.2% within nine years). The fall in investment is transitory, but long lasting, with the impact of the shock starting to be expansionary again after eighteen years. The adjustment is then accomplished in about fifty years (+1%). On the other hand, the stock market peaks within two years (+10.5%), falling thereafter, with a full adjustment accomplished in about fifty years. The productivity shock also has an expansionary impact on both the real wage and employment. The impact on employment peaks within three years (+0.6%), requiring about thirty years to stabilise (the asymptotic impact is about +0.34%). The positive impact of productivity on employment is an important difference relative to what found for the Italian economy. On the other hand, the expansionary impact on the real wage peaks within twenty years (+2%), stabilising within forty years (+1.7%). Moreover, the productivity shock also has an expansionary, but transitory impact on the real interest rate, peaking within five years (+5bp).

Finally, in Figure 5 we plot the responses to the permanent employment shock for the US. The shock bears the interpretation of permanent labour supply shock, since employment and the real wage move in opposite directions. In fact, the shock has an expansionary and permanent impact on employment, which builds up gradually and stabilises within ten years (+1.6%), while the real wage requires about fifty years to fully adjust to the shock (-2.8%). The permanent labour supply shock also exercises an expansionary, but transitory impact on per capita output, consumption and investment. The impact on output peaks within four years (+1.7%), requiring about 35 years to fade away. Consumption and investment follow different adjustment paths. The impact on consumption peaks at the outset (+0.3%) and is partially offset in the following three years (-0.24%). The response of consumption is again positive within six years, and the adjustment is fully accomplished within thirty years. Also the impact on investment is positive at the outset (+2.5%), turning negative in the following two years (-1%), to become expansionary again after three years. The impact of the shock peaks within eight years (+5.2%), taking about sixty years to fade away. Moreover, the shock has a transitory negative impact on the stock market (-9% within two years), with a full adjustment taking place in about thirty years. Finally, the impact on the real interest rate is negative at the outset but offsetting, becoming expansionary within eight years and peaking in about twelve years (+23bp). The real interest rate converges back to the base line within thirty years.

It is interesting to note that productivity shocks exercise similar effects on
output, consumption, the real wage, and the real interest rate in Italy and the US. On the other hand, the adjustment path followed by investment and employment is different. In fact, although the productivity shock has an expansionary impact on investment for both countries, the long-run impact is much stronger for Italy than the US. In addition, the long-run impact on employment is contractionary for Italy and expansionary for the US. The two findings are related and point to labour saving technical progress in Italy only.\textsuperscript{11} This can also explain the different impact of the shock on per capita investment. However, in both cases the long-run impact is not statistically significant.

The responses of output, consumption, investment, the stock market and employment to the permanent employment shock are also similar for the two countries, with Italy showing a slower adjustment of output and consumption relative to employment. On the other hand, the responses of the real wage and the real interest rate follow opposite paths, with wages and the real interest rate increasing in Italy and falling in the US. In adition, while the effect on US wages is permanent, the effect for Italy is only transitory. These findings are interesting and point to important differences in the Italian and US labour markets, the latter showing a stronger reaction to shocks, possibly as a consequence of higher flexibility.

\subsection*{5.5. Long-run growth and income distribution}

Finally, in Figure 6 we report the effects of all the structural permanent shocks on the wage share.\textsuperscript{12} The effects of a permanent productivity shock are similar for both countries. Productivity tends to rise the wage share at the outset (+1\%) for Italy, depressing it in the medium term (-1\% within six years), and increasing it again in the longer run (it peaks again at +1\% within twentyfour years). The expansionary effects on the wage share are long lasting as well, requiring more than sixty years to fade away. On the other hand, for the US the impact is

\footnote{Technical change may lead to substitution from unskilled to skilled work, in addition to substitution away from work as a whole. As documented by Scarpetta - Bassanini - Pilat - Schreyer (2000), both phenomena would seem to hold for Italy, while none of them for the US. In fact, since the 1990s, for Italy there is evidence of skill-biased employment and of an increase in capital intensity, due to a fall in employment. On the other hand, for the US there is evidence of an increase in both skilled and unskilled employment, with capital intensity also increasing, notwithstanding the increase in employment. See also Blanchard (1997). Coherent with Fabiani - Trento (1999), our findings would suggest that similar dynamics have tended to prevail over the time span considered.}

\footnote{Wage share impulse responses have been computed by the appropriate linear transformations of the per capita output and real wage impulse response functions.}
negative at the outset (-0.5%), but is already expansionary within three years. The adjustment is also long lasting, but, differently from Italy, the impact is permanent (about +0.7%). Improvements in the wage share which are determined by productivity advances therefore do not seem to affect negatively supply side conditions, as both investment and output increase.

On the other hand, the permanent employment shock exercises a positive transitory impact on the wage share for Italy and a permanent negative impact for the US. The increase in the wage share for Italy peaks at 2.2% within two years. Then, the wage share declines steadily, converging back to the base line within thirty years. The labour supply shock affects negatively the wage share for the US (-0.8% at the outset), requiring about thirty years to stabilise (-2.8%). Again, the marked differences in the response of the wage share to the permanent employment shock in Italy and the US may be seen as a consequence of different institutional characteristics of the labour market, with wages and employment moving in the same direction in Italy, and in the opposite direction in the US.

The exercise therefore allows to draw the following conclusions. Although for Italy there is no long-run relationship between growth and income distribution, the interaction between growth and income distribution seems to be important over the transitiional dynamics, which, as suggested by the impulse response analysis, may be long lasting. About fifty years seems to be required for the system to converge back to the steady state after a permanent productivity shock has hit the system. The adjustment is quicker in the case of a permanent labour supply shock, requiring about thirty years to be accomplished. Both shocks have an expansionary, but transitory impact on the wage share.

On the other hand, for the US the impact of the productivity and labour supply shocks on the wage share is permanent, with the wage share increasing after a positive productivity shock (although the asymptotic impact may not be statistically significant), and falling after a positive labour supply shock.13

The results suggest that the shocks which explain long-run growth have different effects on income distribution, providing evidence in favour of a mechanism through which growth and income distribution are directly related (productivity shocks) and a mechanism through which growth and income distribution are inversely related (labour supply shocks). Both mechanisms would work through the labour market. The negative impact of the labour supply shock on the wage share can be explained by noting that wages, following an increase in the labour

---

13 Similar responses of the wage share to productivity and labour supply shocks have been documented by Morana (2002) for the UK.
supply, would tend to fall, leaving labour productivity unchanged in the long-run. It would then follow a positive correlation between growth (induced by the labour supply shock) and inequality. Since labour supply is the key growth factor in the initial phase of economic development, this result would also allow to explain the increase in income inequality which is associated with this stage.

Also the medium-long term expansionary impact of productivity on the wage share can be related to the working of the labour market, since technical progress induces an incremental shift in labour demand, which, everything else unchanged, leads to an expansion in employment and the real wage. If the relative change in the real wage is greater than the relative change in productivity, the wage share would tend to increase. This result is plausible since real wages, in addition to growing according to the productivity improvement, would also tend to grow as a consequence of the positive impact of technical progress on employment. A positive correlation between growth (induced by productivity shocks) and income equality would then appear. Since technical progress is a growth factor which may be associated with mature economic development, this would also allow to account for the reduction in inequality which is observed at this stage.14

By jointly considering the two dynamics, we find an explanation for Kuznets’ hypothesis regarding the linkage between growth and income distribution.

An important final result of our analysis is that an explanation for the observed dynamics in income distribution in industrialised countries since the 1970s can be provided. The proposed explanation lies in the tendential developments in labour productivity, strongly growing until the 1970s and decelerating thereafter. According to the impulse response analysis, a positive productivity shock exercises an expansionary impact on the wage share in the medium-long term and a negative impact in the short term. The technological slowdown could be seen as the explanation for the increase in inequality observed since the 1980s. The fact that it is not possible to observe a significant reduction in inequality in the period 1995-1999, which is usually regarded as a period of strong productivity improvements, but possibly only for the period 1999-2001, does not refute the proposed explanation. Some critical authors of the actual spillovers of the “ITC

14 A complementary explanation for this result can be found in Fabiani – Trento (1999). According to these authors, during the phase of mature capitalist development real wages tend to reflect also a compensation for human capital, so that the ratio of the real wage to the unitary cost of physical capital grows more rapidly than capital intensity. As a consequence the wage share would increase. Moreover, since capital intensity has tended to increase at a more rapid pace in Italy than the US, due to the negative impact of technical progress on employment in the former country only, a stronger impact on the wage share should be expected for the US.
revolution” as Gordon (2000b) have suggested that the increase in productivity in the period 1995-1999 in the US economy, computed relatively to the period 1972-1995, has been mostly generated in the durable sector, while the remaining sectors would have only experienced a reduction in productivity. The decomposition suggested by Gordon (2000b) points to a total increase of productivity equal to 1.35%, of which 0.54% can be associated with cyclical factors and 0.81% to structural factors. The structural increase would have been generated in the ICT sector, and induced positive spillovers in the durable sector. On the other hand, the non durable sector would have experienced a reduction in productivity equal to -0.28%.15 Keeping into account the short term negative impact of productivity shocks on the wage share, in addition to the documented productivity dynamics, it is then possible to understand why the wage share has not started increasing in the mid 1990s. This conclusion is also consistent with previous results of Morana (2002) for the UK.

From our analysis it emerges a causal linkage from growth to income distribution, explained by productivity and labour supply shocks, working through the labour market. While permanent employment shocks may depress the wage share, positive productivity shocks depress initially the wage share, but lead to its improvement in the longer run. These beneficial effects seem to be stronger in a flexible economy (the US) than in a more regulated economy (Italy). It follows that fluctuations in income inequality should be expected as a consequence of economic growth. It also follows that an economic policy aiming at long-run growth and equality should be concerned with the improvement of supply side conditions and the enhancement of productivity advances.

6. Conclusions

In this paper we have analysed the process of long-run growth in Italy and the US over the period 1920-2001, using a common trends model. To account for structural change and make policy analysis more reliable, the common trends model has been derived from a Markov switching-VECM model. The Markov switching mechanism has proved to be a useful tool to detect and model structural change, pointing to an increase in the volatility of the rate of growth of all the

---

15 As documented by Milana - Zeli (2002) and Colecchia - Schreyer (2001), also for Italy there is evidence of a different sectorial impact of ICT investment on productivity, with ICT-using sectors benefiting the most. However, the overall effect of ICT investment seems to be much lower than for the US.
variables during periods which can be associated with the two World Wars and the Great Depression.

In accordance with the neoclassical growth model, we find evidence of stochastic balanced growth and of two engines of growth, namely a permanent technological shock and permanent labour supply shock. The impact of the technological shock on employment is negative for Italy and positive for the US. In addition, for both countries the technological shock has a positive impact on per capita output, consumption, investment, aggregate capital, and the real wage. On the other hand, employment is affected positively by the permanent employment shock, while wages are also affected positively for Italy, but negatively for the US. Then, the shock bears the interpretation of labour supply shock for the US, and labour demand shock for Italy. This latter shock is also expansionary, but transitory on per capita output, consumption, and investment, while has a contractionary impact on the stock market.

As revealed by the impulse response analysis, following a productivity shock the transition to the steady state may be a lengthy process, requiring more time for Italy (about fifty years) than for the US (about thirty years). This suggests that the interaction between income distribution and growth may be of empirical interest. We find that, following a productivity shock, inequality fluctuates, increasing in the short-run and decreasing in the longer term, while the employment shock (labour supply shock for the US; labour demand shock for Italy) affects positively the wage share in Italy and negatively in the US. By jointly considering the negative impact of the labour supply shock and the positive impact of the productivity shock, it is then possible to provide an explanation for the observed correlation between growth and income distribution during the phases of economic development, since labour supply shocks may be held to be more important in the initial phases of economic development and technological shocks in the successive phases. However, the linkage between growth and income distribution is not causal but consequential, since growth shocks are primitive shocks relative to wage share shocks. Hence, fluctuations in income distribution should be expected as a consequence of economic growth.

References


Table 1, Panel A: Italy
Cointegration analysis

<table>
<thead>
<tr>
<th>Eigenvalue</th>
<th>0.539</th>
<th>0.499</th>
<th>0.356</th>
<th>0.279</th>
<th>0.210</th>
<th>0.091</th>
<th>0.026</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothesis:</td>
<td>$r = 0$</td>
<td>$r \leq 1$</td>
<td>$r \leq 2$</td>
<td>$r \leq 3$</td>
<td>$r \leq 4$</td>
<td>$r \leq 5$</td>
<td>$r \leq 6$</td>
</tr>
<tr>
<td>$\lambda_{TRACE}$</td>
<td>212.4**</td>
<td>148.9**</td>
<td>92.27**</td>
<td>56.18**</td>
<td>29.35*</td>
<td>9.97</td>
<td>2.18</td>
</tr>
<tr>
<td>95% crit. value</td>
<td>124.2</td>
<td>94.2</td>
<td>68.5</td>
<td>47.2</td>
<td>29.7</td>
<td>15.4</td>
<td>3.8</td>
</tr>
<tr>
<td>90% crit. value</td>
<td>118.5</td>
<td>89.5</td>
<td>64.8</td>
<td>43.9</td>
<td>26.8</td>
<td>13.3</td>
<td>2.7</td>
</tr>
</tbody>
</table>

$r$ denotes the number of valid cointegrating vectors; ** denotes significance at the 5% level, * denotes significance at the 10% level.

Restricted cointegrating vectors
($\beta'$ matrix; cointegrating vectors normalised on $c$, $i$, $f$, $w$, and $r$ respectively)

<table>
<thead>
<tr>
<th></th>
<th>$y$</th>
<th>$c$</th>
<th>$i$</th>
<th>$f$</th>
<th>$w$</th>
<th>$e$</th>
<th>$r$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Likelihood-ratio tests: $\chi^2(4) = 15.576$ (p-value: 0.016)

<table>
<thead>
<tr>
<th></th>
<th>$y$</th>
<th>$c$</th>
<th>$i$</th>
<th>$f$</th>
<th>$w$</th>
<th>$e$</th>
<th>$r$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Likelihood-ratio tests: $\chi^2(8) = 16.393$ (p-value: 0.037)
Table 1, Panel B: US
Cointegration analysis

<table>
<thead>
<tr>
<th>Eigenvalue:</th>
<th>0.553</th>
<th>0.496</th>
<th>0.259</th>
<th>0.251</th>
<th>0.203</th>
<th>0.084</th>
<th>0.007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothesis:</td>
<td>( r = 0 )</td>
<td>( r \leq 1 )</td>
<td>( r \leq 2 )</td>
<td>( r \leq 3 )</td>
<td>( r \leq 4 )</td>
<td>( r \leq 5 )</td>
<td>( r \leq 6 )</td>
</tr>
<tr>
<td>( \lambda_{\text{TRACE}} )</td>
<td>196.9**</td>
<td>130.8**</td>
<td>74.69**</td>
<td>50.1**</td>
<td>26.45</td>
<td>7.79</td>
<td>0.56</td>
</tr>
<tr>
<td>95% crit. value</td>
<td>124.2</td>
<td>94.2</td>
<td>68.5</td>
<td>47.2</td>
<td>29.7</td>
<td>15.4</td>
<td>3.8</td>
</tr>
<tr>
<td>90% crit. value</td>
<td>118.5</td>
<td>89.5</td>
<td>64.8</td>
<td>43.9</td>
<td>26.8</td>
<td>13.3</td>
<td>2.7</td>
</tr>
</tbody>
</table>

\( r \) denotes the number of valid cointegrating vectors;
** denotes significance at the 5% level, * denotes significance at the 10% level.

Restricted cointegrating vectors
(\( \beta' \) matrix; cointegrating vectors normalised on \( c, i, f, w \) and \( r \), respectively)

<table>
<thead>
<tr>
<th>( y )</th>
<th>( c )</th>
<th>( i )</th>
<th>( f )</th>
<th>( w )</th>
<th>( e )</th>
<th>( r )</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-1.059)</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(0.034)</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(-1.967)</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(0.321)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1.613</td>
<td>0</td>
</tr>
<tr>
<td>(-2.105)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>(0.099)</td>
<td>(0.099)</td>
</tr>
<tr>
<td>(0.050)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Likelihood-ratio tests: \( \chi^2(5) = 11.703 \) (\( p \)-value: 0.039)

<table>
<thead>
<tr>
<th>( y )</th>
<th>( c )</th>
<th>( i )</th>
<th>( f )</th>
<th>( w )</th>
<th>( e )</th>
<th>( r )</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-1)</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(-1)</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(-1)</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(-2.315)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1.705</td>
<td>0</td>
</tr>
<tr>
<td>(0.086)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>(0.106)</td>
<td>(0.106)</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Likelihood-ratio tests: \( \chi^2(8) = 18.779 \) (\( p \)-value: 0.016)

34
Table 2, Panel A: Italy
Regime-switching analysis

<table>
<thead>
<tr>
<th>Transition matrix</th>
<th>Shock regime</th>
<th>Non-shock regime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shock regime</td>
<td>0.968</td>
<td>0.160</td>
</tr>
<tr>
<td>Non-shock regime</td>
<td>0.032</td>
<td>0.840</td>
</tr>
<tr>
<td>Duration</td>
<td>6</td>
<td>31</td>
</tr>
<tr>
<td>Number of observations</td>
<td>18</td>
<td>65</td>
</tr>
</tbody>
</table>

\[ p_{ij} = \Pr\{s(t) = i \mid s(t - 1) = j\} . \]

Estimated variance-covariance matrix
Shock Regime
(Non-shock regime)

<table>
<thead>
<tr>
<th></th>
<th>(\Delta y)</th>
<th>(\Delta c)</th>
<th>(\Delta i)</th>
<th>(\Delta f)</th>
<th>(\Delta w)</th>
<th>(\Delta e)</th>
<th>(\Delta r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\Delta y)</td>
<td>0.0162</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.0003</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\Delta c)</td>
<td>0.0042</td>
<td>0.0034</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.0002</td>
<td>0.0003</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\Delta i)</td>
<td>0.0244</td>
<td>0.0095</td>
<td>0.0891</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.0004</td>
<td>0.0003</td>
<td>0.0015</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\Delta f)</td>
<td>0.0623</td>
<td>0.0040</td>
<td>0.0746</td>
<td>0.3374</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.0005</td>
<td>0.0007</td>
<td>0.0021</td>
<td>0.0021</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\Delta w)</td>
<td>-0.0046</td>
<td>0.0011</td>
<td>-0.0031</td>
<td>-0.0335</td>
<td>0.0146</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.0001</td>
<td>0.0001</td>
<td>-0.0003</td>
<td>-0.0003</td>
<td>-0.0003</td>
<td>0.0009</td>
<td></td>
</tr>
<tr>
<td>(\Delta e)</td>
<td>-0.0015</td>
<td>-0.0006</td>
<td>-0.0002</td>
<td>-0.0027</td>
<td>-0.0001</td>
<td>0.0005</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.0001</td>
<td>-0.0001</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0002</td>
<td></td>
</tr>
<tr>
<td>(\Delta r)</td>
<td>1.320</td>
<td>0.1315</td>
<td>0.9695</td>
<td>6.1421</td>
<td>-0.9107</td>
<td>-0.1217</td>
<td>154.19</td>
</tr>
<tr>
<td></td>
<td>-0.0148</td>
<td>-0.0000</td>
<td>-0.0446</td>
<td>-0.0869</td>
<td>0.0431</td>
<td>-0.0009</td>
<td>11.674</td>
</tr>
</tbody>
</table>
Table 2, Panel B: US
Regime-switching analysis

<table>
<thead>
<tr>
<th>Transition matrix</th>
<th>Shock regime</th>
<th>Non-shock regime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shock regime</td>
<td>0.947</td>
<td>0.168</td>
</tr>
<tr>
<td>Non-shock regime</td>
<td>0.053</td>
<td>0.832</td>
</tr>
</tbody>
</table>

| Duration          | 6            | 19               |
| Number of observations | 23          | 58               |

\[ p_{ij} = \Pr\{s(t) = i \mid s(t - 1) = j\}. \]

Estimated variance-covariance matrix
Shock Regime
(Non-shock regime)

<table>
<thead>
<tr>
<th></th>
<th>(\Delta y)</th>
<th>(\Delta c)</th>
<th>(\Delta i)</th>
<th>(\Delta f)</th>
<th>(\Delta w)</th>
<th>(\Delta e)</th>
<th>(\Delta r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\Delta y)</td>
<td>0.0029</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.0002</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\Delta c)</td>
<td>-0.0002</td>
<td>0.0018</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.0001</td>
<td>0.0001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\Delta i)</td>
<td>0.0009</td>
<td>0.0054</td>
<td>0.0635</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.0005</td>
<td>0.0002</td>
<td>0.0018</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\Delta f)</td>
<td>0.0045</td>
<td>0.0033</td>
<td>0.0461</td>
<td>0.0611</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.0004</td>
<td>0.0005</td>
<td>0.0007</td>
<td>0.0129</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\Delta w)</td>
<td>0.0012</td>
<td>0.0000</td>
<td>-0.0032</td>
<td>-0.0018</td>
<td>0.0023</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.0001</td>
<td>0.0000</td>
<td>0.0001</td>
<td>0.0003</td>
<td>0.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\Delta e)</td>
<td>0.0012</td>
<td>-0.0006</td>
<td>0.0043</td>
<td>0.0054</td>
<td>0.0001</td>
<td>0.0018</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0002</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0001</td>
</tr>
<tr>
<td>(\Delta r)</td>
<td>-0.0531</td>
<td>0.1178</td>
<td>-0.8465</td>
<td>-0.6730</td>
<td>0.0484</td>
<td>-0.2363</td>
<td>59.925</td>
</tr>
<tr>
<td></td>
<td>0.0046</td>
<td>0.0038</td>
<td>0.0107</td>
<td>0.0213</td>
<td>0.0024</td>
<td>0.0001</td>
<td>0.903</td>
</tr>
</tbody>
</table>
Table 3, Panel A: Italy
Regime-switching analysis

*Estimated factor loading matrix*
(\(\alpha\) matrix, standard errors in parenthesis)

<table>
<thead>
<tr>
<th></th>
<th>(c - y)</th>
<th>(i - y)</th>
<th>(f - y)</th>
<th>(w - y)</th>
<th>(r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(y)</td>
<td>-0.265*</td>
<td>-0.002</td>
<td>0.019*</td>
<td>0.135*</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>(0.059)</td>
<td>(0.018)</td>
<td>(0.005)</td>
<td>(0.026)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>(c)</td>
<td>-0.129*</td>
<td>0.015</td>
<td>0.012*</td>
<td>0.105*</td>
<td>-0.000</td>
</tr>
<tr>
<td></td>
<td>(0.059)</td>
<td>(0.015)</td>
<td>(0.005)</td>
<td>(0.026)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>(i)</td>
<td>-0.352*</td>
<td>-0.247*</td>
<td>0.052*</td>
<td>0.361*</td>
<td>0.003*</td>
</tr>
<tr>
<td></td>
<td>(0.137)</td>
<td>(0.039)</td>
<td>(0.013)</td>
<td>(0.061)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>(f)</td>
<td>-2.867*</td>
<td>-0.540*</td>
<td>-0.102</td>
<td>0.715*</td>
<td>0.014*</td>
</tr>
<tr>
<td></td>
<td>(0.577)</td>
<td>(0.115)</td>
<td>(0.065)</td>
<td>(0.288)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>(w)</td>
<td>-0.004</td>
<td>0.058*</td>
<td>-0.010</td>
<td>-0.081*</td>
<td>-0.001</td>
</tr>
<tr>
<td></td>
<td>(0.092)</td>
<td>(0.026)</td>
<td>(0.009)</td>
<td>(0.042)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>(e)</td>
<td>0.125*</td>
<td>0.006</td>
<td>-0.002</td>
<td>-0.046*</td>
<td>-0.000</td>
</tr>
<tr>
<td></td>
<td>(0.030)</td>
<td>(0.026)</td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>(r)</td>
<td>16.29*</td>
<td>-2.651</td>
<td>-1.683*</td>
<td>-9.511*</td>
<td>-0.119*</td>
</tr>
<tr>
<td></td>
<td>(0.350)</td>
<td>(1.508)</td>
<td>(0.519)</td>
<td>(0.488)</td>
<td>(0.047)</td>
</tr>
</tbody>
</table>

* denotes significance at the 5% level.

**Specification tests: standardised residuals**

<table>
<thead>
<tr>
<th></th>
<th>(\Delta y)</th>
<th>(\Delta c)</th>
<th>(\Delta i)</th>
<th>(\Delta f)</th>
<th>(\Delta w)</th>
<th>(\Delta c)</th>
<th>(\Delta r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BL(10)</td>
<td>0.714</td>
<td>0.194</td>
<td>0.462</td>
<td>0.264</td>
<td>0.078</td>
<td>0.497</td>
<td>0.313</td>
</tr>
<tr>
<td>BL2(10)</td>
<td>0.296</td>
<td>0.572</td>
<td>0.647</td>
<td>0.226</td>
<td>0.065</td>
<td>0.062</td>
<td>0.185</td>
</tr>
<tr>
<td>Normality</td>
<td>0.001</td>
<td>0.010</td>
<td>0.997</td>
<td>0.523</td>
<td>0.000</td>
<td>0.093</td>
<td>0.483</td>
</tr>
</tbody>
</table>

BL(n) and BL2(n) is the Box-Ljung test for serial correlation up to the \(n\)th order in the actual and squared standardised residuals, respectively, Normality is the Bera-Jarque normality test.
Table 3, Panel B: US
Regime-switching analysis

*Estimated factor loading matrix*
\[(\alpha \text{ matrix, standard errors in parenthesis)}\]

<table>
<thead>
<tr>
<th></th>
<th>(c - y)</th>
<th>(i - y)</th>
<th>(f - y)</th>
<th>(w - y)</th>
<th>(r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(y)</td>
<td>0.012</td>
<td>-0.011</td>
<td>0.001</td>
<td>0.016*</td>
<td>-0.001</td>
</tr>
<tr>
<td></td>
<td>(0.037)</td>
<td>(0.012)</td>
<td>(0.007)</td>
<td>(0.003)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>(c)</td>
<td>-0.114*</td>
<td>0.019</td>
<td>0.012*</td>
<td>0.028*</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.035)</td>
<td>(0.010)</td>
<td>(0.005)</td>
<td>(0.009)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>(i)</td>
<td>0.750*</td>
<td>-0.092*</td>
<td>-0.072*</td>
<td>-0.258*</td>
<td>-0.001</td>
</tr>
<tr>
<td></td>
<td>(0.159)</td>
<td>(0.039)</td>
<td>(0.022)</td>
<td>(0.055)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>(f)</td>
<td>-0.029</td>
<td>0.080</td>
<td>-0.028</td>
<td>0.201*</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>(0.425)</td>
<td>(0.072)</td>
<td>(0.051)</td>
<td>(0.201)</td>
<td>(0.006)</td>
</tr>
<tr>
<td>(w)</td>
<td>0.017</td>
<td>-0.011</td>
<td>0.009*</td>
<td>0.023*</td>
<td>-0.003*</td>
</tr>
<tr>
<td></td>
<td>(0.022)</td>
<td>(0.007)</td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>(e)</td>
<td>0.327*</td>
<td>-0.022*</td>
<td>-0.029*</td>
<td>-0.134*</td>
<td>-0.001</td>
</tr>
<tr>
<td></td>
<td>(0.025)</td>
<td>(0.008)</td>
<td>(0.004)</td>
<td>(0.003)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>(r)</td>
<td>-12.513*</td>
<td>2.289*</td>
<td>-0.095</td>
<td>6.899*</td>
<td>-0.488*</td>
</tr>
<tr>
<td></td>
<td>(2.861)</td>
<td>(0.928)</td>
<td>(0.382)</td>
<td>(0.101)</td>
<td>(0.058)</td>
</tr>
</tbody>
</table>

* denotes significance at the 5% level.

**Specification tests: standardised residuals**

<table>
<thead>
<tr>
<th></th>
<th>(\Delta y)</th>
<th>(\Delta c)</th>
<th>(\Delta i)</th>
<th>(\Delta f)</th>
<th>(\Delta w)</th>
<th>(\Delta e)</th>
<th>(\Delta r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(BL)</td>
<td>0.461</td>
<td>0.828</td>
<td>0.627</td>
<td>0.415</td>
<td>0.120</td>
<td>0.917</td>
<td>0.141</td>
</tr>
<tr>
<td>(BL_2)</td>
<td>0.218</td>
<td>0.272</td>
<td>0.798</td>
<td>0.766</td>
<td>0.290</td>
<td>0.622</td>
<td>0.774</td>
</tr>
<tr>
<td>Normality</td>
<td>0.428</td>
<td>0.942</td>
<td>0.817</td>
<td>0.263</td>
<td>0.355</td>
<td>0.947</td>
<td>0.005</td>
</tr>
</tbody>
</table>

\(BL(n)\) and \(BL_2(n)\) is the Box-Ljung test for serial correlation up to the \(n\)th order in the actual and squared standardised residuals, respectively, Normality is the Bera-Jarque normality test.
Table 4, The estimated common trends model

Panel A: Italy

<table>
<thead>
<tr>
<th>Variable</th>
<th>Shock</th>
<th>$\tau_\theta$</th>
<th>$\tau_\xi$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y - e$</td>
<td>6.464</td>
<td>(2.657)</td>
<td></td>
</tr>
<tr>
<td>$c - e$</td>
<td>6.852</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$i - e$</td>
<td>7.305</td>
<td>(3.003)</td>
<td></td>
</tr>
<tr>
<td>$f - e$</td>
<td>6.464</td>
<td>(2.657)</td>
<td></td>
</tr>
<tr>
<td>$w$</td>
<td>6.464</td>
<td>(2.657)</td>
<td></td>
</tr>
<tr>
<td>$e$</td>
<td>-1.488</td>
<td>2.158</td>
<td>(1.221)</td>
</tr>
<tr>
<td>$r$</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Panel B: US

<table>
<thead>
<tr>
<th>Variable</th>
<th>Shock</th>
<th>$\tau_\theta$</th>
<th>$\tau_\xi$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y - e$</td>
<td>0.995</td>
<td>(0.298)</td>
<td></td>
</tr>
<tr>
<td>$c - e$</td>
<td>0.995</td>
<td>(0.298)</td>
<td></td>
</tr>
<tr>
<td>$i - e$</td>
<td>0.995</td>
<td>(0.298)</td>
<td></td>
</tr>
<tr>
<td>$f - e$</td>
<td>0.995</td>
<td>(0.298)</td>
<td></td>
</tr>
<tr>
<td>$w$</td>
<td>1.726</td>
<td>(1.612)</td>
<td>-2.804</td>
</tr>
<tr>
<td>$e$</td>
<td>0.339</td>
<td>1.644</td>
<td></td>
</tr>
<tr>
<td>$r$</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

$\tau_\theta$ denotes the permanent technological shock, while $\tau_\xi$ denotes the permanent labour supply shock.
Figure 1: Estimated smoothed probabilities.
Figure 2: Italy, responses to technology shock: per capita output (y), per capita consumption (c), per capita investment (i), per capita real stock market index, employment (e), real wage (w), real interest rate (r). All the variables, apart from the real interest rate, are in logs. Standard errors have been computed through Monte Carlo simulation with 1000 replications.
Figure 3: Italy, responses to labour supply shock: per capita output (y), per capita consumption (c), per capita investment (i), per capita real stock market index, employment (e), real wage (w), real interest rate (r). All the variables, apart from the real interest rate, are in logs. Standard errors have been computed through Monte Carlo simulation with 1000 replications.

42
Figure 4: US, responses to technology shock: per capita output (y), per capita consumption (c), per capita investment (i), per capita real stock market index, employment (e), real wage (w), real interest rate (r). All the variables, apart from the real interest rate, are in logs. Standard errors have been computed through Monte Carlo simulation with 1000 replications.
Figure 5: US, responses to labour supply shock: per capita output (y), per capita consumption (c), per capita investment (i), per capita real stock market index, employment (e), real wage (w), real interest rate (r). All the variables, apart from the real interest rate, are in logs. Standard errors have been computed through Monte Carlo simulation with 1000 replications.
Figure 6: Responses of the wage share (ws) to technology shock (1) and labour supply shock (2). Standard errors have been computed through Monte Carlo simulation with 1000 replications.