WP/10/244

IMF Working Paper

After the Crisis: Assessing the Damage in Italy

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INTERNATIONAL MONETARY FUND

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After the Crisis: Assessing the Damage in Italy

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October 2010

Abstract

Italy's deep-rooted structural problems resulted in an unsatisfactory productivity performance and a dismal growth over the last 15 years. The global financial crisis has exacerbated these long-standing weaknesses, taking a heavy toll on Italy's economy. With output back to its end-2001 level, Italy's output losses associated with the crisis have been, thus far, about 132 billion of 2000 euro (around 10 percent of precrisis 1998–2004 real GDP). About three quarters of these losses are estimated to be due to a shortfall in potential output. Potential output is not expected to rebound to its precrisis trend over the medium term, even though growth is projected to do so within the next two years. In the short-run, the decline in output is mainly accounted for by a collapse in productivity; in the medium term, employment and capital are also likely to be affected, with implications for the longer-term growth and fiscal outlook.

JEL Classification Numbers: C22; C32; E32.

Keywords: Potential output, productivity growth; output losses

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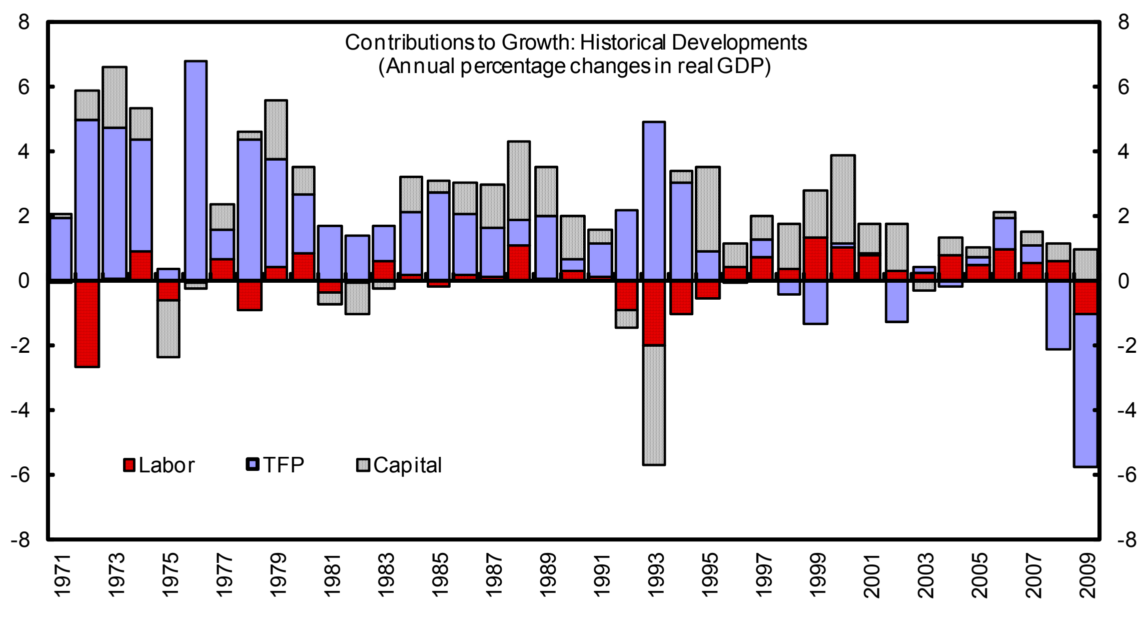
I. Introduction

The financial crisis will likely have a long-lasting impact on Italy's economic potential. Indeed, innovation and investment opportunities may weaken because demand prospects are likely to be poor and the real cost of borrowing remains high. In addition, some of the increase in unemployment may be structural given that displaced workers will find it hard to return to the labor market as industrial restructuring takes hold.

Against this backdrop, this paper assesses Italy's medium-term output losses following the crisis and their implications for the longer-term growth outlook and the fiscal situation. It argues that Italy's deep-rooted structural problems—giving rise to unsatisfactory productivity growth—had weakened the Italian economy long before the financial crisis. Using a variety of techniques, results suggest that output is not expected to rebound to its precrisis trend over the medium term. Unless policy actions are taken, structural weaknesses will continue to weigh on the Italian economy even when the recovery takes place.

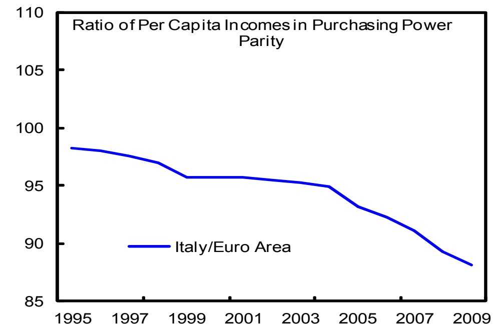
II. Productivity: Italy's Achilles' heel

Italy has suffered from chronically low economic growth, even before the global financial crisis. Real GDP growth averaged 1.6 percent during the period 1995–2007, down from over 2 percent in the earlier decade (Figure 1).



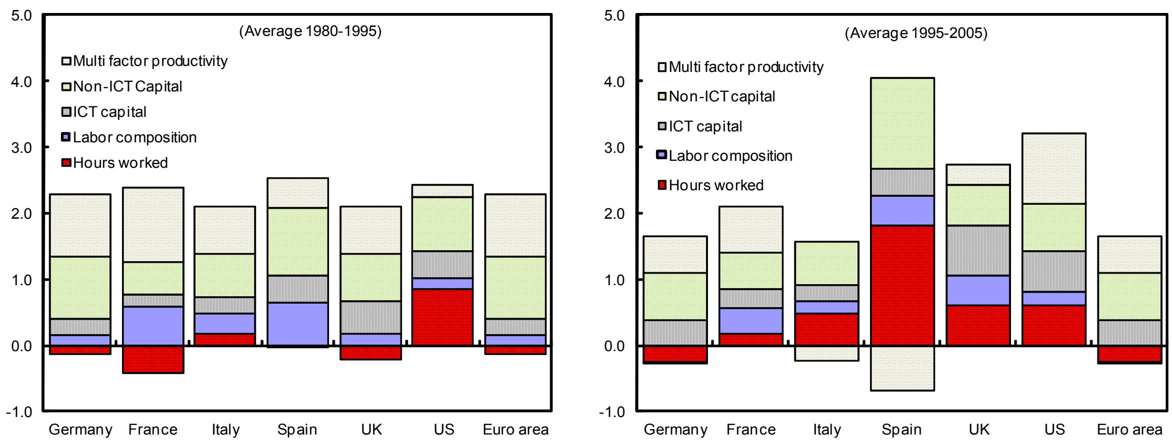
Sources: OECD; and IMF staff calculations.

Before the crisis, the Italian economy underperformed most of its euro area peers. Over the last decade, Italy's GDP moved gradually away from the EU15 benchmark, with average annual growth almost one percentage point lower than the average Correspondingly, Italy's per capita income (measured in purchasing power parity) has declined, diverging away from the euro area over the same period.



Source: WEO.

Figure 1: Contribution to GDP growth
(Percent change)



Sources: EU Commission; and IMF staff calculations.

Italy's dismal growth performance is largely due to poor productivity. Breaking down GDP growth into labor, capital, and total factor productivity (TFP) contributions shows that the Italian economy's anemic growth is mostly explained by the declining TFP. In fact, TFP contributions decreased substantially over the period 1995–2005—a slowdown which was pervasive across all sectors but especially pronounced in manufacturing and non-tradable sectors. Besides, the reallocation of employment from sectors with higher productivity (typically manufacturing) to sectors with lower productivity (typically services) would not be large enough to justify a sizeable impact on the whole economy.[1]

[1] On this point, see also Daveri and Jona Lasinio, 2005.

Table 1. Italy: Gross Value Added Growth and Contributions 1/
(Percent, annual average volume growth rates)

		Contribution of						
	VA (1)= (2)+(5)+(8	L (2)= (3)+(4)	H (3)	LC (4)	K (5)= (6)+(7)	KIT (6)	KNIT (7)	MFP (8)
1980-1995								
Total industries	2.11	0.49	0.19	0.30	0.89	0.25	0.64	0.73
Manufacturing	2.22	-0.94	-0.99	0.05	0.94	0.19	0.75	2.22
Electricity, gas and water supply	1.65	0.37	0.32	0.06	2.60	0.27	2.33	-1.32
Construction	0.08	-0.33	-0.35	0.01	0.51	0.09	0.41	-0.10
Wholesale and retail trade	0.08	-0.33	-0.35	0.01	0.51	0.09	0.41	-0.10
Hotels and restaurants	0.96	2.63	2.52	0.11	0.27	0.04	0.22	-1.94
Transport, storage and communication	3.71	1.13	1.05	0.07	1.15	0.69	0.46	1.43
Finacial intermediation	1.31	1.50	1.28	0.22	1.70	1.18	0.52	-1.89
Business activities	3.48	2.37	2.25	0.12	1.39	0.21	1.18	-0.27
Personal and social services	1.63	1.60	1.99	-0.39	0.51	0.18	0.34	-0.49
1995-2005								
Total industries	1.33	0.66	0.49	0.17	0.91	0.25	0.66	-0.24
Manufacturing	-0.15	-0.22	-0.41	0.18	0.80	0.21	0.59	-0.73
Electricity, gas and water supply	0.87	-0.91	-0.91	0.00	1.20	0.16	1.03	0.58
Construction	1.78	1.48	1.33	0.15	1.30	0.14	1.17	-1.00
Wholesale and retail trade	1.78	1.48	1.33	0.15	1.30	0.14	1.17	-1.00
Hotels and restaurants	1.50	2.04	1.86	0.18	0.97	0.12	0.85	-1.52
Transport, storage and communication	3.68	0.80	0.66	0.14	1.41	0.32	1.09	1.47
Finacial intermediation	0.74	-0.08	-0.18	0.10	0.16	0.77	-0.61	0.66
Business activities	2.21	1.82	1.71	0.11	0.83	0.23	0.60	-0.44
Personal and social services	1.19	0.78	0.95	-0.17	0.68	0.24	0.44	-0.27

Source: EU KLEMS database.

1/ Where, VA=Gross value added growth; L=Labor input growth; H=Total hours worked; LC=Labor composition; K=Capital input growth; KIT=ICT capital; KNIT=Non-ICT capital; MFP=Multi factor productivity growth.

By contrast, the contribution of labor growth has been positive over recent years. While contribution of capital remained broadly stable, contribution of hours worked increased significantly—also relatively to the EU15—thanks to extensive labor market reforms. Within the labor factor, labor participation accounted for almost half of the annual GDP growth in 2001–2007. The contribution of employment was also substantial, while that of average hours worked was marginally negative. In addition, there was a strong contribution from immigration.

The contrasting movements of labor and total factor productivity may be partly an (unwanted) effect of sweeping labor market reforms. A significant trade-off between employment and productivity can be observed since 1997. As firms responded to labor market reforms by shifting to less capital-intensive production methods, a somewhat reduced rate of capital deepening had to be expected. Moreover, regularization of the illegal immigrant work force may have contributed to bringing to light irregular employment, which had not previously been included in estimates, thereby depressing measured productivity growth.

Some of the policy reforms implemented in Italy may have boosted employment per capita but depressed productivity in the short run. Indeed, if labor demand does not shift when labor market reforms occur, then labor supply shifts to the right along a given labor demand curve, causing productivity to slow down as a result.[2] This could have been the case in Italy, following the changes in labor market legislation in favor of more flexibility. Nevertheless, it is striking that the drop in the TFP growth since the mid-1990s has largely offset the increase in labor supply following the reforms.

Protracted sluggishness in productivity growth may also conceal economic features, including:

- Relatively high tax ratios, deemed to have undercut Italy's growth performance by discouraging labor supply and investment;

- A heavy regulatory burden in labor and product markets and bureaucratic red tape, likely to have hampered competition and stifled incentives to invest;

- A large share of small and medium-size enterprises, which might have hobbled productivity growth by limiting the scope for economies of scale and technology transfers.

Indeed, the presence of such rigidities—along with an industrial specialization in products with relatively low value added—may also have contributed to Italy's steady erosion of competitiveness, as highlighted by the significant decline in Italy's world market share in world trade since the mid-1990s (even compared to its peers).

III. The Crisis: A New Toll on Productivity

The global financial crisis took a toll on Italy's economy. The downturn in Italy started earlier and has been deeper and longer-lasting than in most of its euro area peers. Output contracted by 1.3 percent in 2008 and 5.0 percent in 2009. The recession in Italy's main trading partners led to a sharp fall in exports. Investment dropped more sharply than in earlier recessions reflecting weak demand prospects, while inventories were cut. Despite strong household balance sheets, private consumption also declined significantly, possibly reflecting uncertainty, rising unemployment, and tighter consumer credit, and was only marginally offset by the modest rise in government consumption.

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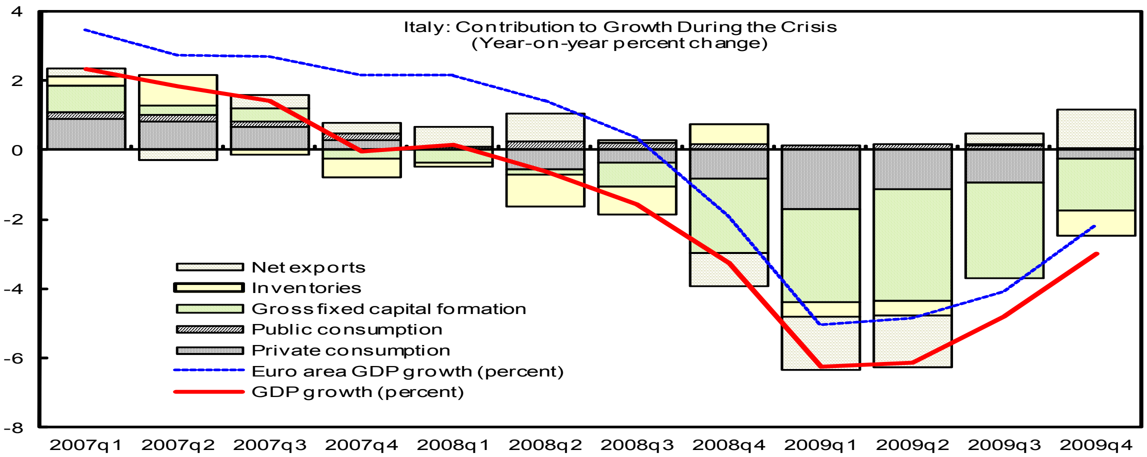
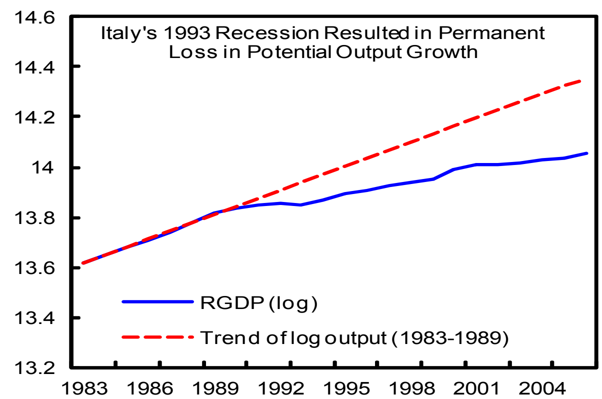
[2] On this point, see evidence in Gordon and Dew-Becker (2008).



Source: Eurostat.

The economy suffered the worst recession since World War II. The collapse in economic activity was far more severe than the one experienced during the 1974–75 oil-price crisis and the 1992–93 EMS crisis (Figure 2). In the first quarter of 2009, growth witnessed a decline in growth of 6 percent (year-on-year), four times as large as the one experienced during the EMS crisis.[3] Additionally, growth was starting from weaker initial conditions. More importantly, following the EMS crisis, output did not recover to its precrisis trend (1983–89), resulting in permanent loss in potential output growth in the long run.[4] The most distinguishing feature of this recession was the sharp deterioration of exports (Italy's traditional engine of growth). The globally synchronized nature of this recession led to the largest historical contraction of Italian exports since the 1930s. As a result, investment dropped sharper than experienced in earlier recessions. On the other hand, the profile of decline in private consumption was similar, though more persistent.



Sources: Eurostat; and IMF staff calculations.

Since the onset of the crisis, productivity has plummeted even further, exacerbating Italy's long-standing structural weaknesses (Table 1). As a result, unit labor costs have soared and profitability has been further squeezed, worsening Italy's already weak competitive position. On the other hand, capital deepening has—thus far—been showing

[3] See Bassanetti, et al. (2009) for a comparison of historical recessions in Italy.

[4] Data is not available to examine the recovery to pre-crisis trend for other historical recessions.

strong resilience, while unemployment has been rising only modestly, largely due to part-time work schemes and declining hours worked. Regrettably, the drop in TFP growth over 2008–09 has been so large it has offset most of the resilience in capital and—to a lesser extent—employment.

Table 2. Contributions to Growth in Times of Crisis

Looking at contributions to growth...

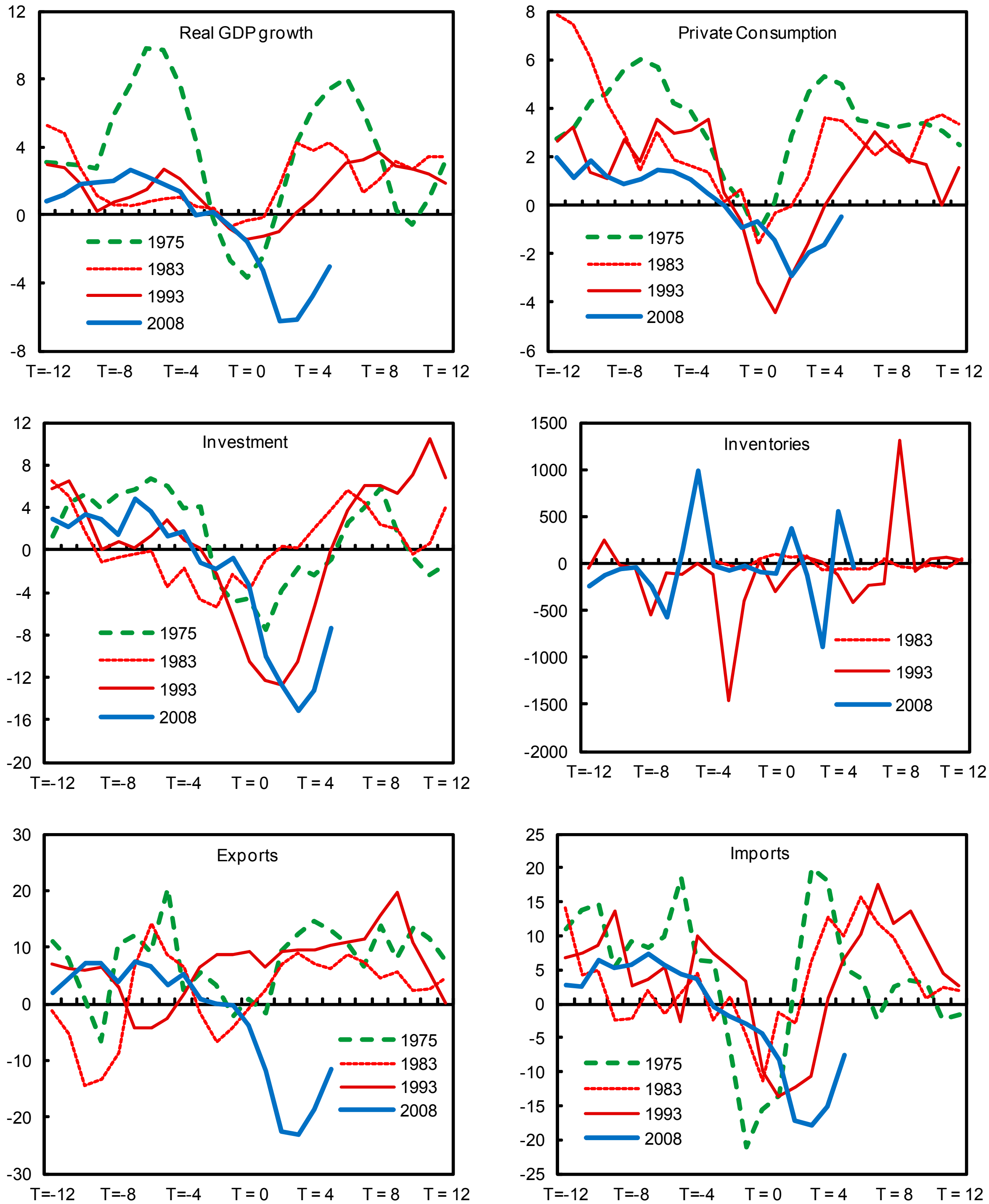
	Labor					Capital			TFP	GDP
	Total Hours Worked	Average Hours Worked	Employment	Labor force	Working-age Population	Total	IT	NIT		
Oil crisis	-0.6	-1.0	-0.3	0.3	0.4	-1.7	0.0	-1.7	0.3	-2.0
76-92	0.1	-0.1	-0.2	0.0	0.4	0.6	-0.2	0.8	2.1	2.8
Currency crisis	-2.0	0.1	-0.8	-1.5	0.2	-3.7	-4.2	0.5	4.8	-0.9
94-07	0.4	-0.1	0.2	0.4	0.0	1.0	0.1	0.9	0.2	1.6
Financial crisis	-0.2	-0.2	-0.5	0.2	0.3	0.7	-0.4	1.1	-3.5	-2.9

Looking at capital deepening...

	Capital Deepening	TFP	Labor Productivity
Oil Crisis	-1.4	0.3	-1.1
76-92	0.6	2.1	2.7
Currency Crisis	-2.8	4.8	2.1
94-07	0.7	0.2	0.9
Financial Crisis	0.9	-3.5	-2.6

Sources: ISTAT; EU Commission; OECD; and IMF staff calculations.

Figure 2. Comparing Recessions
(Year-on-year change, Index, Trough=100)



Sources: Eurostat; and Istituto Nazionale di Statistica.

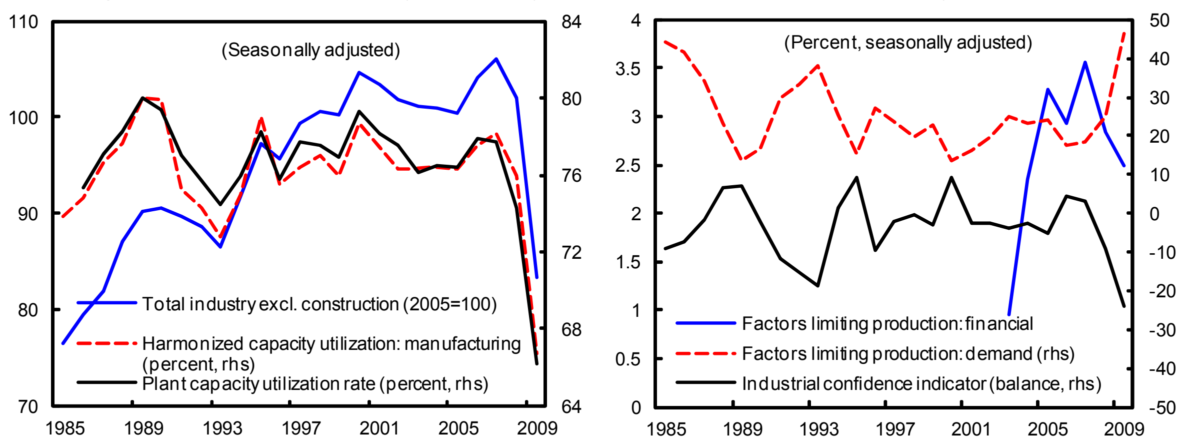
IV. Alternative Ways to Disentangle Temporary from Permanent Losses

It is very difficult to assess how much of the observed decline in output is associated with a persistent (but temporary) demand shock versus supply factors. A sudden collapse in activity could be the result of a severe and long-lasting demand shock or the outcome of a structural change in the economy, such as an increase in natural rate of unemployment or a sectoral reallocation of production factors. While the latter would translate into a permanent loss in potential output, the former would translate into a temporary increase in the size of the output gap.

The crisis has induced an unprecedented fall in output, which is likely to have broken down previous economic relationships. While in normal times business cycle fluctuations account for most of the output volatility; in times of crisis, structural changes may occur, contributing substantially (and more than usual) to output movements.

Survey measures of capacity utilization and expected capacity constraints indicate that the adverse demand shocks started in late 2008. There is evidence that financial conditions had tightened before the collapse in capacity utilization at the onset of the crisis. However, during 2009, demand collapsed and this limited production (Figure 3).

Figure 3. Demand or Supply? Capacity Utilization and Expected Capacity Constraints



Sources: IST; EUCOM; and ISAE Haver.

Sources: European Commission; and Haver Analytics.

Several approaches have been used in this paper to assess the impact of the crisis on potential output performance. None of them is deemed to be perfect or superior, but each offers some insight into this difficult issue:

Statistical approaches. They offer the advantage of using information from the past, while being internally consistent, but the results may not be robust in periods of large structural changes. Among these we consider:[5]

a) the univariate Hodrick-Prescott (HP) filter,

b) and two multivariate unobserved component models:

   i. a multivariate filter (MV), and

   ii. a production function approach (PFA).

Historical approach. Evidence from previous international crises is also considered. Unlike some statistical methodologies, this approach does not impose any priori restrictions on the analysis and can therefore offer an alternative more judgmental perspective.

Univariate two-sided filter

Despite its simplicity, the HP filter has a number of shortcomings. The HP filter only uses the data for the series itself, hence ignoring other relevant economic information. It extracts the trend component, balancing a good fit of actual series with the smoothness of the trend. In addition, the results are not model-based and are prone to "end-point bias," which becomes a significant problem considering the substantial revisions of recent estimates (Appendix I). Generally, the approach is useful for historical analysis but not well-suited for forward looking analysis.

Estimates of potential output and potential labor productivity based on a two-sided moving average smoothing procedure (the HP filter) point to a pre-existing weakness in labor productivity trend growth (Figure 4)**.** However, because of the "end-point" problem intrinsic to the two-sided moving average smoothing procedure, trend measures based on HP-filtering procedure generally prove unreliable, especially if a prolonged recession or a structural break occurs at the end of the sample, as it was indeed the case with the outbreak of the crisis.

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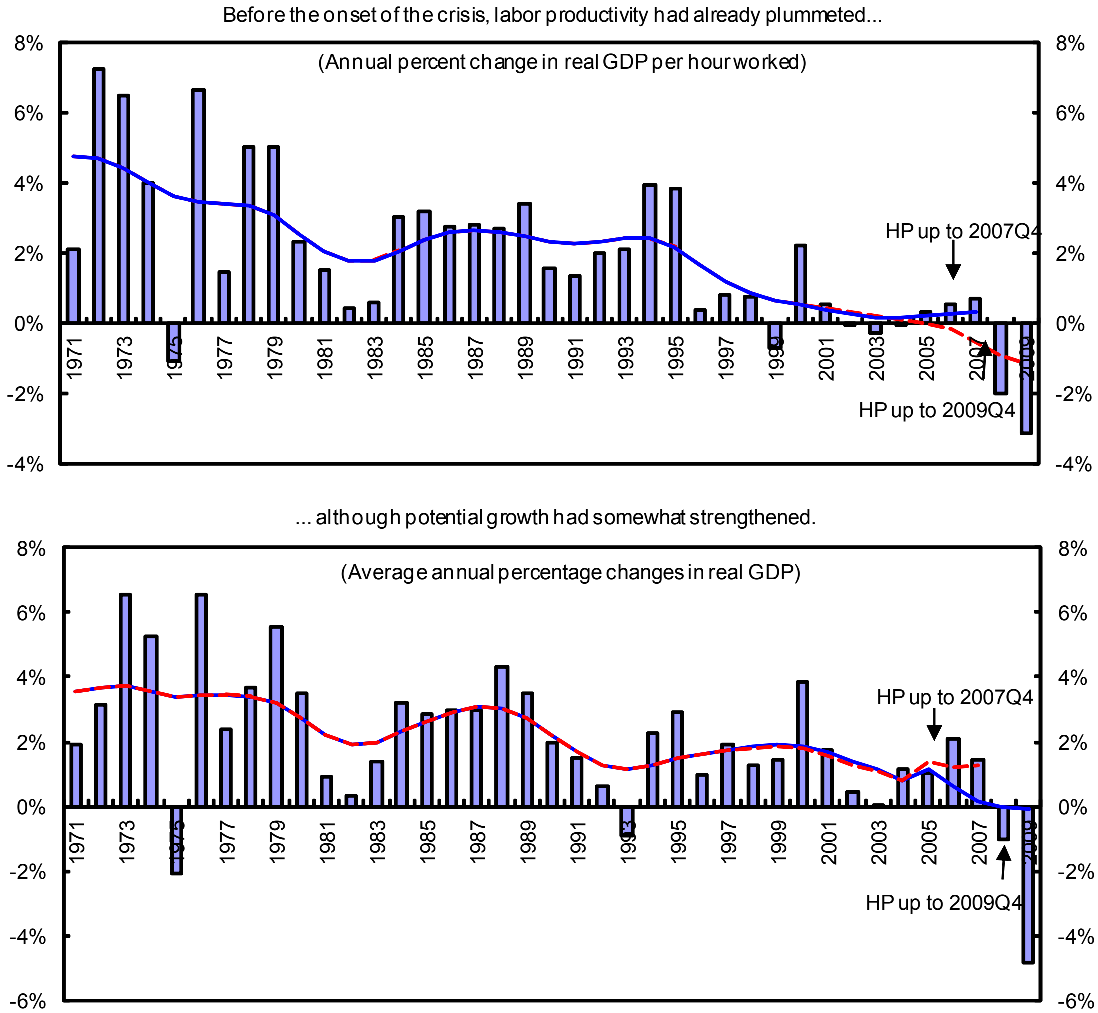
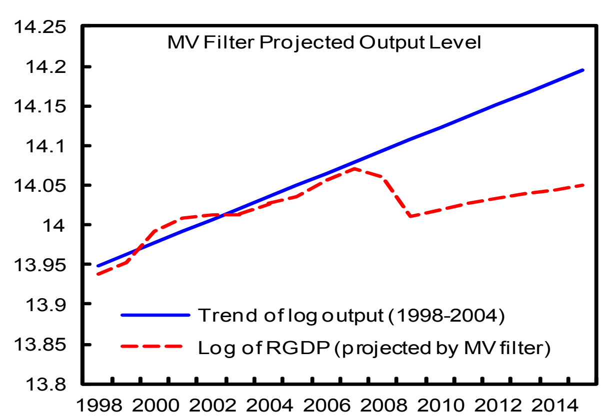
[5] While the HP filter imposes restrictions on the shape of the cyclical and trend component of real output, which may not hold after the crisis, the two multivariate unobserved component models have the merit of extracting long-term trends by exploiting additional information about short-run relationships, like the unemployment-inflation trade-off (in the case of the MV filter), or the productivity-capacity utilization relation (in the case of the PFA). The analytical underpinnings of a multivariate filter and a production function approach with unobserved stochastic components are reported in Appendix II and Appendix III, respectively.

Figure 4. Looking at Potential and Labor Productivity Growth Using HP Trends



Sources: ISTAT; EU Commission; OECD; and IMF staff calculations.

A multivariate (MV) filter



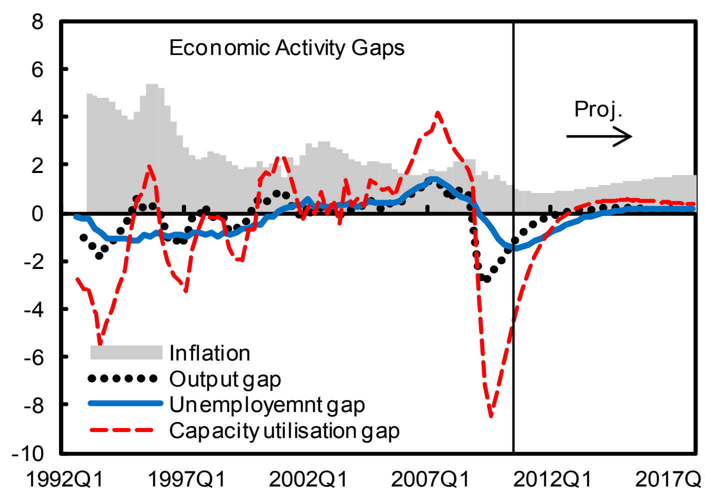
Sources: Eurostat; and IMF staff calculations.

A key advantage of the Multivariate (MV) filter is that it incorporates both recent data and long-term trends (Appendix II). The approach uses a small macroeconomic model to estimate the empirical relationships between actual and potential GDP, unemployment, core inflation, and capacity utilization in manufacturing. Note that this approach assumes that the relationships between the major economic variables were stable despite the large shocks associated with the crisis. In this sense, the approach provides the counterfactual of what would be the dynamics if this were a "normal" recession (i.e. a recession for which only the size of the shock was large but without any structural break).

The MV filter estimates positive output gaps for 2005–08. The results of this filter contrast with the IMF's historical estimates, suggesting that the potential output levels were overestimated. Similarly, the model estimates negative output gap for 2009-2011, which are smaller than current projections. The model projects its closure by 2012. The projected real GDP level suggests an output loss of about 14 percent relative to precrisis trend (1998–2004) by 2015.

The output gap is estimated to have declined sharply in 2009, with gradual improvements thereafter. Italy's output gap is estimated to have troughed at about minus 2 percent in 1993 during the European Monetary System (EMS) crisis. Output subsequently expanded; and in the years 2000–07 the estimated output gap is mostly positive. With the 2008–09 recession, the estimated gap shows a sharper drop, to a trough of about minus 2.5 percent. The model forecasts a negative output gap of minus 1.3 percent for 2010, which gradually declines to minus 0.4 percent in 2011 before closing in 2012. The economy is expected to converge to its steady state growth by 2012. The 2-standard-deviation confidence band is about +/- 1 percent of the estimated potential growth for Italy. The behavior of inflation is consistent with the model's output gap dynamics. Italy's core inflation declined during periods with negative output gap, and rose during the years with positive gap.

The NAIRU is expected to rise moderately. The estimated NAIRU peaked in 1998, and then gradually declined before climbing up toward the end of 2009. The decline during 2008 and beginning of 2009 is likely due to the discouraged worker effect and the falling participation rates. The model, however, forecasts the NAIRU for Italy to increase by only 0.2 during 2008–10, well below the estimated 1–2 percentage rise points in most countries projected by Benes et al (2010), reflecting the measures introduced in Italy for temporary lay-off and work reducing measures. The unemployment gap closes by 2014, reflecting persistence in labor market. The NAIRU's return to the steady state rate is slow.

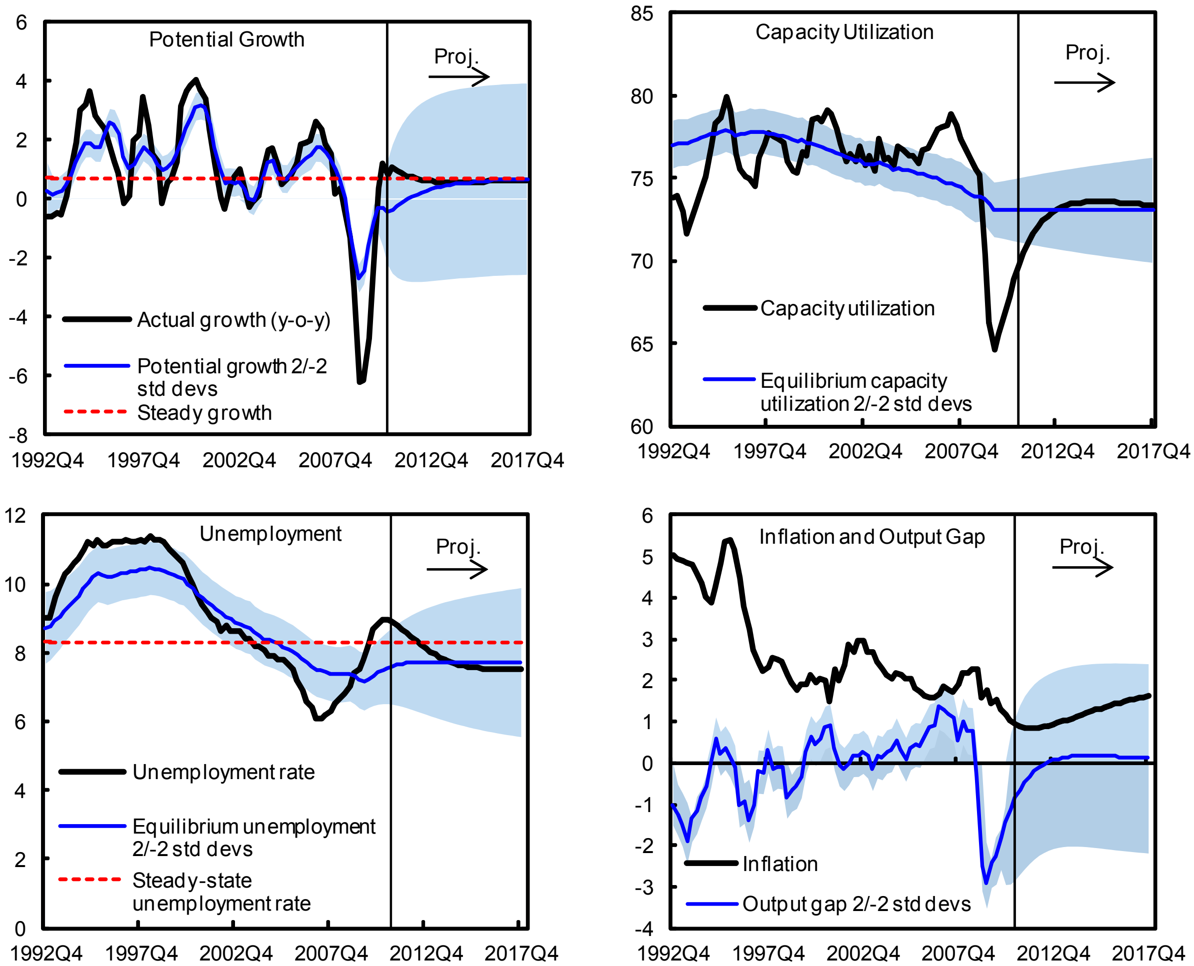


Source: IMF staff calculations.

The recoveries in output and utilization gaps are expected to move in tandem, while the unemployment gap lags behind. The above figure portrays the dynamics of the estimated gaps for output, unemployment rate, and capacity utilization. The unemployment gap is influenced by the current and lagged output gap but has smaller cyclical fluctuations. The smooth profile of the unemployment gap is associated with labor hoarding and the "discouraged worker" effect during recessions. The utilization gap exhibits more volatility with sharp declines during recessions. In particular, the utilization gap declined to in 1993 and to over 8 percent in 2009. Following the 2009 trough, the capacity utilization and the output gaps rebound, closing by 2012. In contrast, the recovery of the unemployment gap lags behind, closing by 2014.

There is a high degree of uncertainty around the forecast. While the multivariate filter projects the output gap to close by 2012, there is a high degree of uncertainty around this forecast with confidence bands widening to about 4 percentage points (-2 to +2 percent). Figure 5 illustrates the estimated year-on-year potential output growth, and the historical and projected real GDP growth. While the estimated growth of potential is correlated with actual growth, the path of potential growth is rather smooth. As expected, fluctuations in output are found to be mainly driven by demand shocks in the short-term and by movements in potential output in the long-term.

Figure 5. Short- and Medium-term Forecasts Based on a MV Approach



Source: IMF staff calculations.

A Production Function Approach

A production function approach (PFA) with unobserved stochastic components offers another perspective on potential output (Appendix III). The rationale for this approach is to estimate potential output from the trend levels of its structural determinants, such as productivity and factor inputs.[6]

[6] Using a production function, such trend levels are extracted by taking into account the relationships between the cyclical components of output and unemployment, the link between cyclical productivity and cyclical hours worked, as well as the impact of the business cycle on labor supply dynamics. Estimates are carried out using real-time data and a Bayesian framework. In order to use sufficiently long quarterly frequency time series, a PFA must usually rely on low-quality data on capital stocks and hours worked, raising issues on whether the TFP component will be spuriously contaminated by measurement problems.

Estimates from PFA show that the major source of potential growth variation is associated with changes in labor participation. The bulk of the *permanent* variation in output is found to be driven by shifts in labor trends, namely labor participation and employment. Conversely, *cyclical* variations in real GDP are mainly driven by (total factor) productivity fluctuations.

While TFP is found to be highly pro-cyclical, the dynamics of its structural component markedly diverge from those of potential output. Since the mid-1990s, TFP growth has declined from one percent to zero. On the contrary, potential growth has risen from an annual rate of 0.7 percent at the end of 1992–93 recession to over 2 percent just before the current slowdown—a growth rate analogous to that of the early 1990s. Finally, there seems to be a constant wedge between the trend growth in labor and factor productivity, confirming the idea that the rate of capital deepening has remained stable over time, at around 1 percent.

TFP and hours worked are strongly pro-cyclical. Both have dramatically plunged below trend since 2002 and have become more pro-cyclical since 1999. The unemployment rate is found to be significantly countercyclical and—consistently with previous model estimates—to fall by about 0.04 percent as output rises 1 percent above potential. Interestingly, labor participation is found to be broadly acyclical, whereas there is evidence of positive comovements between average hours worked per employee, output, and productivity, once structural shifts in factor trends have been identified. Implied output gap estimates tend to exhibit higher volatility than corresponding estimates from the MV approach.[7]

The projected real GDP level suggests an output loss of about 11 percent relative to precrisis trend (1998–2004) by 2015. Output gap derived from the PFA is estimated to have troughed in 2009 at 2.6 percent. Potential output growth is likely to have dropped by 2.7 percent in 2009, but is expected to increase to 0.4 percent in 2010 before reaching its steady-state rate of 0.8 percent. The NAIRU is estimated to rise gradually, from 7.2 in 2009 to 7.9 percent by 2014, when the unemployment gap is also expected to be reabsorbed (Table 2).

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[7] Because of the high volatility of the Solow residual, conditioning real-time output decomposition upon indicators of demand pressures in product and labor market provides smoother estimates of potential growth than unobserved component models relying on a production function approach.

Table 3. Summary of Economic Indicators Implied by the PFA
(Annual percentage change, unless noted otherwise)

	2009	2010	2011	2012	2013	2014
Real GDP	-5.2	0.9	1.6	1.4	1.2	1.1
Resource utilization						
Potential GDP	-2.7	0.4	0.8	0.8	0.8	0.8
Output gap (percent of	-2.6	-2	-1.2	-0.6	-0.3	-0.1
Natural rate of unemployment	7.2	7.7	7.8	7.8	7.8	7.9
Employment	-0.8	-0.4	0.1	0	0	0
Unemployment rate (percent)	7.6	7.9	7.9	7.9	7.9	7.9
Prices						
Labor productivity	-3.2	-1.8	0	0.2	0.3	0.4

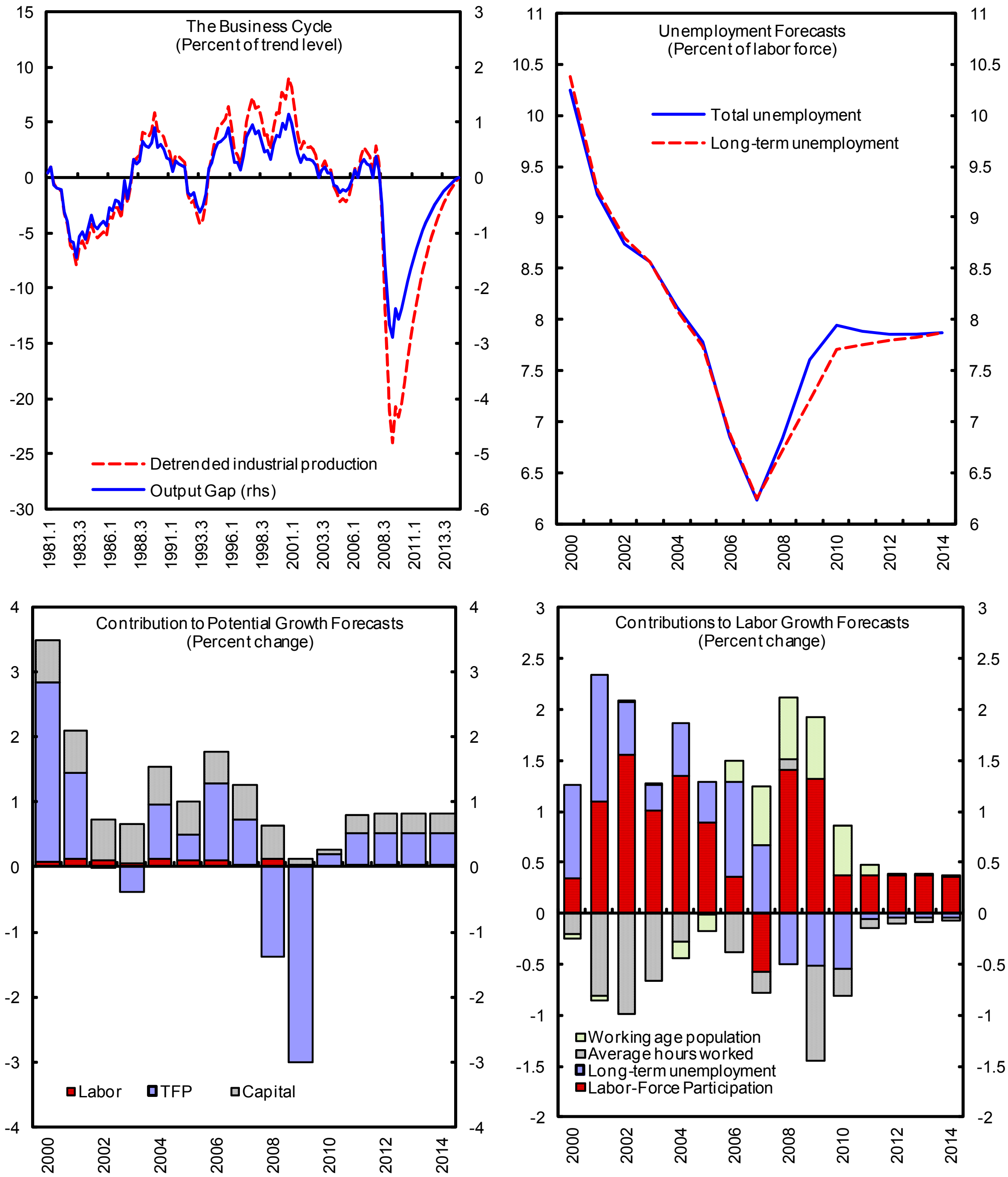
Sources: National Authorities; and IMF staff calculations.

Evidence from previous international episodes

Output performance in the aftermath of past financial crises can offer useful insights into the medium-term recovery prospects. IMF (2009) studied the medium-term output dynamics after financial crises over the past four decades across a wide range of countries. This examined the impact of initial conditions on post-crisis medium-term output losses. The initial conditions considered include those for output, investment, macroeconomic imbalances, level of income and financial development, openness, external conditions, and whether the financial crisis is accompanied by a currency crisis. Estimated OLS coefficients in IMF (2009) are here applied to calculate the impact of the global financial crisis on Italy's medium term output level (Table 3).

Based on this approach, the medium-term output is estimated to decline by about 15 percent relative to the precrisis trend but some caveats should be noted. The medium-term output is estimated to decline by about 15 percent relative to the precrisis trend, well above the 10 percent average found for historical international financial crisis episodes in IMF (2009). The result was driven by a high precrisis investment share of GDP, which was found to be highly correlated with negative capital dynamics following historical international financial crises. Indeed, evidence shows that countries with high precrisis investment to GDP ratios during the three years preceding the crisis experienced large output losses. Another key contributing factor is Italy's large initial output loss during the crisis—the variable most associated with medium-term output performance—confirming the view that the permanent toll of the crisis on economic activity has been exacerbated by Italy's deep-rooted structural weaknesses. This finding suggests that postcrisis macroeconomic policies could play a role in shaping medium-term dynamics—an issue worth examining here.

Figure 6: Short- and Medium-term Forecasts Based on a Production Function Approach



Sources: ISTAT; EU Commission; OECD; and IMF staff calculations.

Table 4. Output Losses versus Initial Conditions

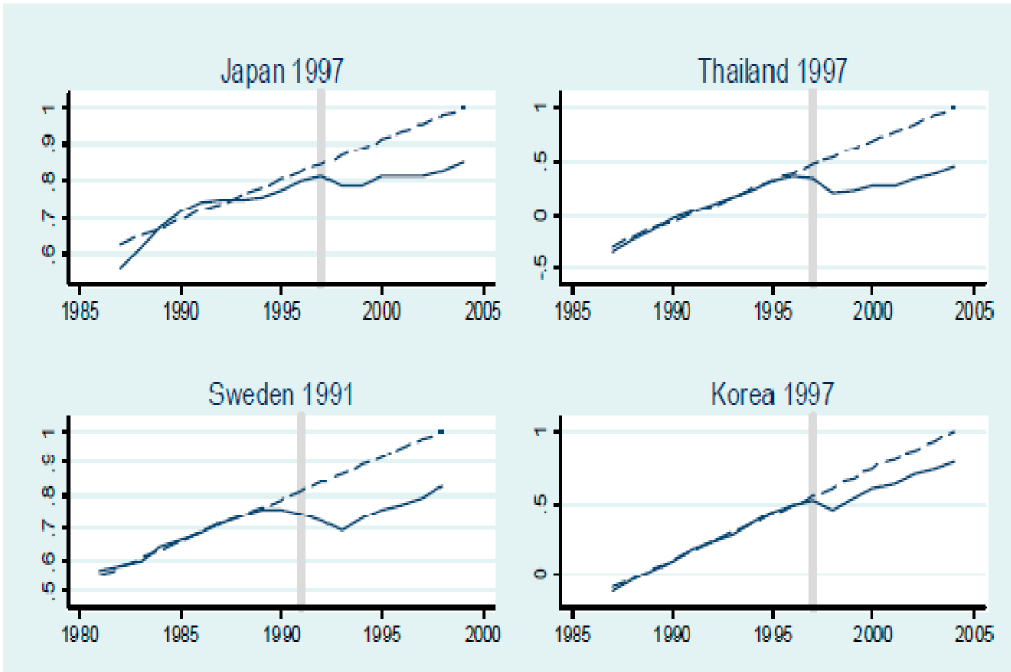
(Dependent variable: output at t=7 in percent of precrisis trend)

	Contribution	Variable definition
Investment/GDP	-0.255	Average gross fixed capital formation to GDP ratio during the three pre-crisis years.
Investment/GDP gap	-0.009	Deviation from historical average (based on the seven-year period ending three years before the crisis) of the investment to GDP ratio during the three pre-
Current account/GDP	-0.001	Average current account to GDP ratio during the three years before the crisis.
Current account/GDP gap	-0.011	Deviation from historical average (based on the seven-year period ending three years before the crisis) of current account to GDP during the three pre-crisis
Inflation	0.0001	Average inflation during the three years before the crisis.
Inflation gap	0.0001	Deviation from historical average (based on the seven-year period ending three years before the crisis) of inflation during the three pre-crisis years.
Fiscal balance	0.016	Average gerneral government overal fiscal balance to GDP ratio during the three years before the crisis.
Fiscal balance gap	-0.002	Deviation from historical average (based on the seven-year period ending three years before the crisis) of overall fiscal balance during the three pre-crisis
Log (PPP GDP per capita)	0.039	Average of the logarithm of output per capita of GDP per capita at purchasing power parity during the three years before the crisis.
Credit/GDP	-0.028	Average credit to GDP ratio during the three years before the crisis.
Credit/GDP gap	0.070	Deviation from historical average (based on the seven-year period ending three years before the crisis) of credit to GDP ratio during the three pre-crisis years.
Currency crisis	0	Dummy=1 if the financial crisis coincides with a curreny crisis, and zero otherwise.
U.S. Treasury bill rate	0.042	Three-month U.S. Treasury bill rate obtained from Thomson Datastream.
External demand shock	0	A dummy variable that equals one if partner-countries' growth is in the worst 10 percent over the last 40 years, and zero otherwise.
Financial openness/GDP	0.016	The sum of foreign assets and foreign liabilities divided by GDP, using the External Wealth of Nations Mark II Database (see Lane and Milesi-Ferretti,
Trade openness/GDP	-0.017	The sum of exports and imports divided by GDP.
Precrisis output	-0.010	Deviation from historical average (based on the seven-year period ending three years before the crisis) of output during the three pre-crisis years.
First-year output change	-0.127	Deviation from historical average (based on the seven-year period ending three years before the crisis) of output during the crisis year.
Constant term	0.125	

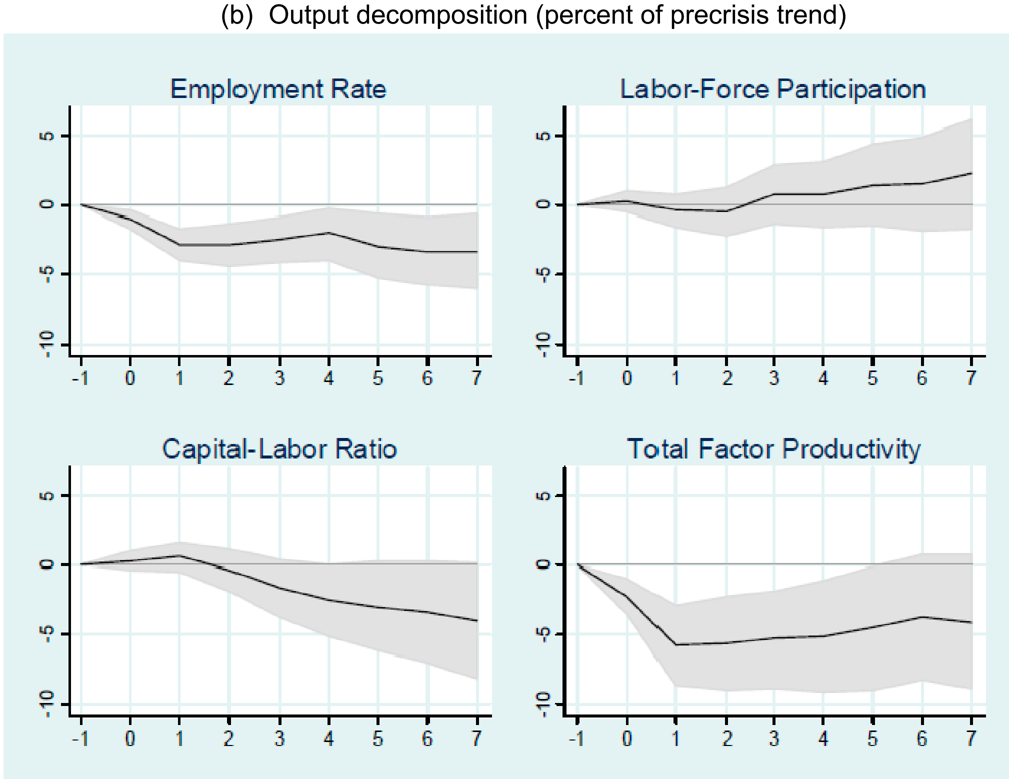
Note: The table reports contributions of respective variables for Italy based on estimated coefficient of ordinary least squares reported in IMF(2009). All the variables, except for the currency crisis and first-year output change, are calculated as average for the three years before the crisis

Figure 7: Evidence From Previous Episodes

(a) Output losses (logs)



(b) Output decomposition (percent of precrisis trend)



Sources: World Economic Outlook (2009); and Abiad and others (2009).

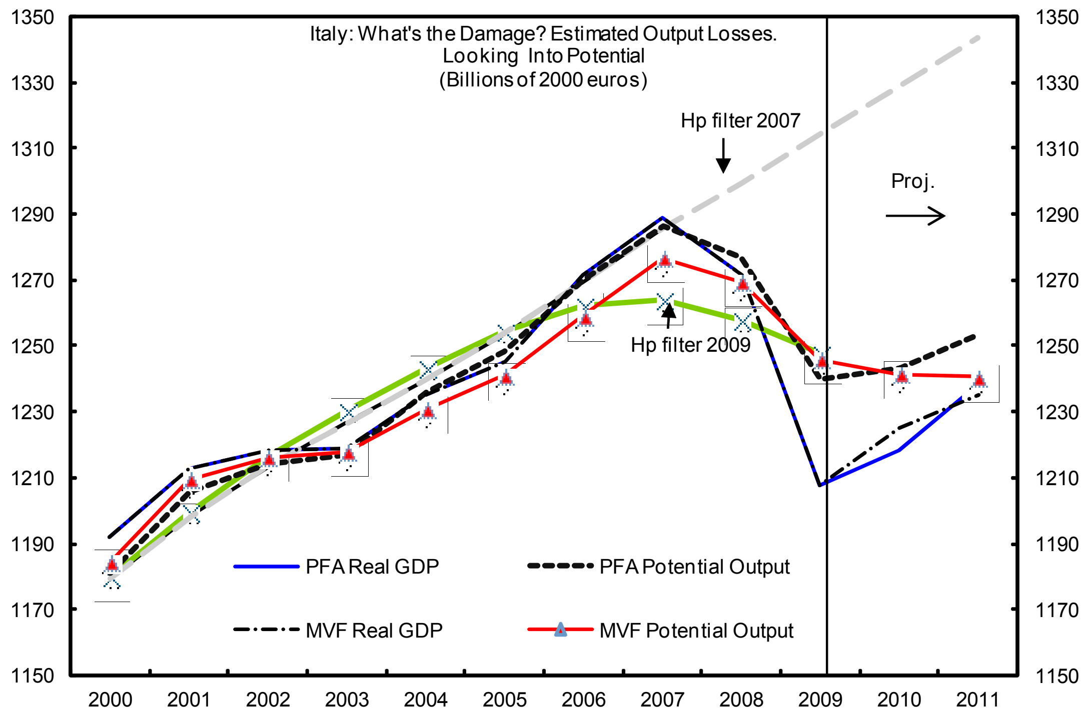
Summary of results

Summary of Estimated Output Losses Relative to Precrisis Trend (1998-2004)

	2015
Multivariate Filter	-14
Production function framework	-11
Evidence from previous epidsodes	-15

A significant permanent output loss will likely be the legacy of the global financial crisis. With output back to its end-2001 level, Italy's output losses associated with the crisis at the end of 2009 are estimated to be about 125 billion of 2000 euro (about 10 percent of precrisis 1998–2004 real GDP). Three quarters of these losses are estimated to be related to shortfalls in potential output. The path of output level is not expected to rebound to its precrisis trend over the medium term, even though growth is projected to do so within the next two years. In the short-run, the decline in output growth is mainly accounted for by a collapse in productivity growth. Over the medium term, productivity is likely to recover and contribute to potential output growth by approximately 0.5 percent, while employment is deemed to suffer more enduring losses. Similarly, capital accumulation is expected to remain weak over 2010 and, in the medium term, to contribute to growth slightly less than used to. The estimated output loss by 2015 relative to precrisis trend (1998–2004) ranges between 11 to 15 percent using different methodologies.

Stronger fiscal adjustment will be required. The profile of potential output and the output gap projected by the MV filter and the PFA implies that the fiscal structural deficits are underestimated. Looking forward, there will be a need for a stronger adjustment effort than the current projections entail, and for reforms to stimulate faster growth. With the forecasted real GDP growth, the consolidation envisaged in the authorities' latest Stability Program would still not be sufficient to ensure a sustained reduction in public debt. With lower real GDP growth over the medium-term, than currently projected, a stronger, expenditure-based, adjustment effort would be needed to put debt on a declining path. A more front-loaded fiscal adjustment would also help balance, to some extent, the highly unequal intergenerational distribution of the long-term fiscal adjustment arising particularly from the current design of the pension reform.



Sources: ISTAT; and IMF staff calculations.

V. Policy: Limiting the Damage

Downside risks for a permanent loss in potential output growth in the long run remain, especially if the global recovery stalls and financial conditions worsen, adversely impacting investments and total factor productivity growth. As highlighted by evidence from previous crisis episodes, downside risks to the output growth recovery reflect a sharper than expected fall in TFP and capital accumulation during the recession as well as a declining labor participation rate, mainly due to lack of incentives for industrial restructuring.

Policy can also limit the damage. Macroeconomic policies can shape medium-term dynamics by reducing the permanent costs associated to the crisis. In Italy, for example, the wage supplementation fund (*Cassa Integrazione Guadagni)* does involve on-the-job training which could cushion the impact of the crisis on structural unemployment.

But which policy priorities? Applying the Lisbon Assessment Framework (LAF) may help identify policy priorities and areas that could help strengthen medium-term TFP growth, (Table 4). TFP growth is shown to be affected by a number of policies, notably in the areas of R&D and innovation, education, product and capital market regulation, as well as a number of labor market policies aiming at increasing working time and making work pay.

The overall LAF picture shows an improvement in reforms in the corresponding area over 2001–2007 with respect to the EU 15.[8]

The European Economic Recovery Programme (EERP) also called for priority to be given to structural policies. The EERP has called for these measures to be consistent with long-term policy objectives such as those found in the Lisbon Strategy, the smooth functioning of the Single Market, and facilitating a move towards a low-carbon economy. The assessment published by the European Commission services (European Commission 2009), shows that Member States are largely undertaking policy responses in line with these principles.

Despite the above-mentioned progresses, however, the impact on Italy's productivity and economic growth has been limited. This may suggest divergent conclusions: either the effects of the implemented reforms are yet to be felt in Italy, or a lot more is needed for reforms to produce visible results or—and this is also a possibility—reforms are not as growth-inducing as the literature seems to suggest.

If growth cannot be resumed through structural reforms, sizeable fiscal adjustment will be required. With lower real GDP growth over the medium-term than currently projected, a stronger, expenditure-based, adjustment effort would be needed to put debt on a declining path. This calls for a more ambitious fiscal consolidation starting now.

[8] For a recent analysis of Italy reform progresses see also Codogno and Felici (2008).

Table 5: Policy Areas Likely Responsible for GDP Performance

Policy area	Level		Growth	
	(*)	GDP components involved	(*)	GDP components involved
Labour market				
Active labour market policies	S	Youth Participation 25-54 Female Participation 25-54 Male Participation 55-64 Participation		Youth Participation
Making work-pay: interplay of tax and benefit system	S	Youth Participation 25-54 Female Participation 25-54 Male Participation 55-64 Participation	B	Youth Participation Total Factor Productivity
Labour taxation to stimulate labour demand	S			
Job protection and labour market segmentation/dualisation	B	Youth Participation 25-54 Female Participation 25-54 Male Participation 55-64 Participation Total Factor Productivity	S	Youth Participation Total Factor Productivity
Policies increasing working time		Total Factor Productivity		Total Factor Productivity
Specific labour supply measures for women	S	Youth Participation 25-54 Female Participation 55-64 Participation	S	Youth Participation
Specific labour supply measures for older workers	B	55-64 Participation		
Wage bargaining and wage-setting policies	S			
Immigration and integration policies	S	Net migration	B	
Labour market mismatch and labour mobility	B	Youth Participation 25-54 Female Participation 25-54 Male Participation		Youth Participation
Product and capital market regulations				
Competition policy framework	S	Total Factor Productivity Capital Deepening	S	Total Factor Productivity Capital Deepening
Sector specific regulation (telecoms, energy)	S	Total Factor Productivity Capital Deepening		Total Factor Productivity Capital Deepening
Market integration - Openness to trade and investment	S	Total Factor Productivity Capital Deepening Labour Quality		Total Factor Productivity Capital Deepening
Business environment - Regulatory barriers to entrepreneurship	B	Total Factor Productivity Capital Deepening		Total Factor Productivity Capital Deepening
Business Dynamics - Start-up conditions	B	Total Factor Productivity Capital Deepening	B	Total Factor Productivity Capital Deepening
Financial markets and access to finance	S	Total Factor Productivity Capital Deepening		Total Factor Productivity Capital Deepening
Innovation and Knowledge				
R&D and Innovation	B	Labour Quality		Total Factor Productivity Capital Deepening
ICT	S	Total Factor Productivity Capital Deepening		Total Factor Productivity Capital Deepening
Education and life-long learning	B	Youth Participation 25-54 Female Participation 25-54 Male Participation 55-64 Participation Labour Quality (Education) Total Factor Productivity	S	Youth Participation Total Factor Productivity
Macroeconomy				
Orientation and sustainability of public finances	S	Capital Deepening	S	Capital Deepening

(*) Existence of policy issue(s): B= "Broad policy issue" means that the aggregate index shows underperformance (aggregate score is below -4 in Table 2), while S= "Specific policy issue" indicates that only a set of sub-indicators shows underperformance.

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Appendix I. Features and Pitfalls of the HP Filter

The Hodrick-Prescott filter (HP, henceforth) is derived by minimizing the sum of squared deviations of the log variable (e.g. *y,* in the case of GDP) from the estimated trend τ, subject to a smoothness constraint that penalizes squared variations in the growth of the estimated trend series. Thus, HP trend values are those that minimize:

$$\sum_{t=1}^{T}\left(y_t-\tau_t\right)^2+\lambda\sum_{t=1}^{T-1}\left(\left(\tau_{t+1}-\tau_t\right)-\left(\tau_t-\tau_{t-1}\right)\right)^2$$

The estimated trend variable τ is a function of λ and both past and future values of y. Higher values of λ imply a large weight on smoothness in the estimated trend series (for very large values the estimated trend series will converge to a linear time trend; as λ tends to zero, the trend is coincident with the series). Apart from the arbitrary choice of the λ parameter (set to the standard value $100*s^2$, where s denotes the frequency of the series), the decomposition of cycle and trend estimated by an HP filter turns out to be inaccurate under two circumstances:

- **At the end of the sample—**when the HP filter suffers from an in-sample phase shift problem—as it needs to rely on *future* information about the series. The end-period problem can be tackled by extending actual data out of the sample using the information carried by the average historical growth rate or autoregressive forecast models. However, if past growth rates are not reasonable proxies for future growth patterns, this extension may lead to a bias at the end of the filtered series.

- **When cyclical fluctuations are highly persistent** or when underlying trends are subject to temporary stochastic shocks with greater variance than that of the business cycle. Implicit in the choice of λ is, in fact, a strict assumption about the relative importance of supply and demand shocks: e.g., trend fluctuations account for 2½ percent of cyclical fluctuations in quarterly data (or 1 percent in annual data). Although, on average, such an estimate fits output data for industrial countries reasonably well, over relatively short periods this may not be the case.

For both reasons, analyzing macroeconomic fluctuations regarding the on-going prolonged slowdown using HP trends could prove to be misleading.

Appendix II. A Multivariate Filter

The table below presents the equations of the multivariate filter.[9]

MV Model Equations	
$y_t = 100 * LOG(Y_t/\bar{Y}_t)$	(1)
$u_t = \bar{U}_t - U_t$	(2)
$c_t = C_t - \bar{C}_t$	(3)
$\pi 4_t = \pi 4_{t-1} + \beta y_t + \Omega(y_t - y_{t-1}) + \varepsilon_t^{\pi 4}$	(4)
$u_t = \phi_1 u_{t-1} + \phi_2 y_t + \varepsilon_t^u$	(5)
$c_t = k_1 c_{t-1} + k_2 y_t + \varepsilon_t^c$	(6)
$\bar{U}_t = \bar{U}_{t-1} + G_t^{\bar{U}} - \omega y_t - \frac{\lambda}{100}(\bar{U}_{t-1} - U^{ss}) + \varepsilon_t^{\bar{U}}$	(7)
$G_t^{\bar{U}} = (1-\alpha)G_{t-1}^{\bar{U}} + \varepsilon_t^{G^{\bar{U}}}$	(8)
$\bar{Y}_t = \bar{Y}_{t-1} - \theta(\bar{U}_t - \bar{U}_{t-1}) - (1-\theta)(\bar{U}_t - \bar{U}_{t-20})/19 + G_t^{\bar{Y}}$	(9)
$G_t^{\bar{Y}} = \tau G_{ss}^{\bar{Y}} + (1-\tau)G_{t-1}^{\bar{Y}} + \varepsilon_t^{G^{\bar{Y}}}$	(10)
$\bar{C}_t = \bar{C}_{t-1} + G_t^{\bar{C}} + \varepsilon_t^{\bar{C}}$	(11)
$G_t^{\bar{C}} = (1-\delta)G_{t-1}^{\bar{C}} + \varepsilon_t^{G^{\bar{C}}}$	(12)
$\pi 4_t^{LTE} = \pi 4_{t-1}^{LTE} + \varepsilon_t^{\pi 4^{LTE}}$	(13)
$y_t = \rho_1 y_{t-1} - \rho_2(\pi 4_{t-1} - \pi 4_{t-1}^{LTE}) + \epsilon_t^y$	(14)

The model includes output, unemployment, and capacity utilization gaps. Equation (1) defines the output gap y_t as the log difference between actual GDP (Y_t) and potential GDP ($\bar{Y}_t$). The output gap is approximately measured as percent of potential output. The concept of potential output used is the maximum amount of output that can be produced without generating upward or downward pressures for inflation. Equation (2) defines the unemployment gap u_t as the difference between the equilibrium unemployment rate, or NAIRU, ($\bar{U}_t$) and the actual unemployment rate (U_t). A positive unemployment gap indicates excess demand for labor. In equation (3), the capacity utilization gap (c_t) is the difference between the actual manufacturing capacity utilization index (Ct) and its equilibrium level ($\bar{C}_t$).

The model focuses on core inflation to best capture the relationship between excess demand and inflation, avoiding the components of the CPI that change for exogenous reasons. Equation (4) describes the inflation dynamics. The current core inflation is affected by the level (y_t) and the change $(y_t - y_{t-1})$ in the output gap. The output gap displays the influence of excess demand on inflation. If the economy is producing above its potential, i.e., has a positive output gap, inflation will rise. The change in output gap embodies rigidities in

[9] The equations that are presented here are those used for the estimation of the potential output in "The Global Financial Crisis and Its Implications for Potential Output", Forthcoming IMF Working Paper.

the adjustment process of the economy, such as increased structural unemployment following a recession. The previous period inflation, with coefficient set to one, would (i) proxy for inflation expectations, and (ii) entails no long-run tradeoff between inflation and output.

The unemployment dynamics reflect labor market characteristics. Equation (5) identifies the unemployment gap dynamics by the output gap and the lagged unemployment gap. Okun's law suggests a relationship between unemployment and output movements. The lagged unemployment gap is included to reflect the lag between developments in output and unemployment in line with theory and data. Similarly, equation (6) implies a relationship between capacity utilization gap, its lag, and output gap. The evolution of equilibrium unemployment rate, NAIRU, is determined in equation (7). The equilibrium unemployment ($\overline{U}_t$) is influenced by its lag, transitory shocks ($\varepsilon_t^{\overline{U}}$), persistent shocks ($G_t^{\overline{U}}$), the output gap, and difference between current equilibrium unemployment and its steady state level in the long-run(U^{ss}). The specification would take into consideration the persistence in unemployment. The persistent shocks follow an autoregressive process illustrated in equation (8).

Data Sources

Y	Gross Domestic Product (SAAR, Bil.Chn.2000.Euros)
C	Capacity utilization in manufacturing sector (Haver)
$\pi 4_t$	Annual rate of core inflation (Haver)
$\pi 4_t^{LTE}$	Long term inflation expectations (Consensus Economics)
U	Unemployment rate (SA, percent)

The potential output depends on changes in NAIRU and the underlying potential growth trend. In equation (9), the coefficient for first difference of the NAIRU is set to equal the labor share in a Cobb-Douglas production function (θ). The coefficient of the long-run difference (19 quarters) of NAIRU is constrained to (1-θ) so that in the log-run the impact of a permanent changes in NAIRU are fully reflected in the potential output level. The underlying potential growth trend ($G_t^{\overline{Y}}$)follows serially correlated deviations from the steady-state growth rate. The equilibrium capacity utilization ($\overline{C}_t$) also follows a stochastic process with transitory ($\varepsilon_t^{\overline{C}}$) and persistent ($G_t^{\overline{C}}$) shocks. Equation (13) formulates the perceived long-term inflation objective, taking into consideration revisions to previous period expectations captured by ($\varepsilon_t^{\pi 4^{LTE}}$). The historical data for the long-term inflation expectations is obtained from Consensus Economics. In equation (14), the output gap is influenced by monetary policy, while other factors encompassed by the stochastic term(ϵ_t^{y}).

The model is estimated using Bayesian technique. The sample period is 1992Q4 to 2009Q3. We assume a steady-state value of 0.61 for the labor share, 0.7 percent for output growth, and 8.3 percent for the unemployment rate. Table 1 displays prior distributions and estimated posterior distributions. The results are relatively robust as evidenced by the limited sensitivity of the current quarter estimates to new data revisions (Table 2).

Table 1. Maximum Regularised Likelihood

Parameter	Prior		Posterior	
	Mode	Dispersion	Mode	Dispersion
alpha	0.500	0.016	0.496	0.024
beta	0.400	0.032	0.218	0.040
omega	0.500	0.032	0.392	0.045
rho1	0.800	0.016	0.806	0.024
kappa1	0.100	0.063	0.427	0.059
phi1	0.800	0.016	0.813	0.025
phi2	0.300	0.016	0.252	0.024
tau	0.100	0.016	0.113	0.022
delta	0.500	0.016	0.498	0.024
kappa2	1.500	0.158	1.735	0.141
parhist	5.000	0.316	4.925	0.472
rho2	5.000	0.316	5.034	0.468
lambda	1.000	0.316	1.061	0.441
std_RES_Y	1.000	0.032	0.906	0.049
std_RES_G	1.000	0.032	1.038	0.049
std_RES_UNR_GAP	0.500	0.032	0.330	0.044
std_RES_UNR_BAR	0.100	0.016	0.099	0.024
std_RES_UNR_G	0.100	0.016	0.117	0.021
std_RES_CAPU_GAP	0.400	0.032	0.569	0.040
std_RES_CAPU_BAR	0.250	0.016	0.274	0.025
std_RES_CU_G	0.075	0.003	0.076	0.005
std_RES_PIE	0.500	0.032	0.478	0.039
std_RES_PIELTE	0.300	0.032	0.159	0.019

Table 2. Forecasting Accuracy and Revision Robustness

Root Mean Squared Errors				
Parameter	1Q Ahead	4Q Ahead	8Q Ahead	12Q Ahead
LGDP	0.598	1.929	2.882	3.259
PIE4	0.273	0.656	0.826	0.907
UNR	0.228	0.691	1.164	1.421
CAPU	1.043	2.717	3.221	3.067
PIELTE	0.142	0.326	0.453	0.621
Mean absolute revisions (according to most recent estimates)				
quarter	t-12	t-8	t-4	t (nowcast)
Y	0.144	0.176	0.227	0.295
Y (HP)	0.120	0.177	0.327	0.498
UNR_GAP	0.131	0.125	0.110	0.096
UNR_GAP (HP)	0.076	0.070	0.177	0.332

Appendix III. A Production Function with Unobserved Stochastic Components[10]

Output decomposition is further carried out within a production function framework. The rationale is to derive potential output estimates from the trend levels of its structural determinants, such as productivity and factor inputs. In considering a specification of the technology which allows for variable capital utilization, we assume a quite flexible production function:

$$Y_t = A_t (C_t L_t)^{\beta} (C_t K_t)^{1-\beta} \qquad (15)$$

Here, technology has the usual Cobb-Douglas representation with constant returns to scale and perfect market competition.[11] Hence, β is the labor share—measured by the cost of labor services as a share of total costs—*A* represents total factor productivity, *L* denotes total hours worked in the economy, *K* is the capital stock, and *C* is the unobserved degree of capacity utilization—ranging over the interval (0,1]—both labor and capital are adjusted for.[12] Taking logs of both sides of equation (15)—here denoted by small caps—yields:

$$y_t = (a + c) + \beta l_t + (1-\beta) k_t \qquad (16)$$

All factor inputs in equation (16) can be additively decomposed into their (unobserved) permanent (denoted by superscript star) and cyclical (denoted by superscript *c*) components, with the exception of the capital stock, which is assumed to be fully permanent and, hence, to contribute only to potential. While the permanent component of the Solow residual (a^*) is solely driven by technology, the transitory component of the Solow residual (a^c) is likely to absorb all nontechnological effects to productivity as well as fluctuations in the intensity of capital use. As such, the stationary component of the Solow residual is likely to display more business cycle variability than strictly defined TFP. Algebrically:

[10] This appendix draws on Sgherri (2004).

[11] In the model we have in mind, all the non-technological effects (e.g., non-constant returns to scale, imperfect competitions, and input reallocations) considered by Basu, Fernald, and Kimball (2004) and briefly discussed in Section II, do not operate in the long run, so that over long horizons, productivity is solely driven by technology. In particular, whenever a shock increases demand, the increase in production would mandate higher output per firm and would lead to increases in profits. This would spur entry and drive per firm output and profits down to zero. By the same token, in order for increasing returns to contribute to long-run productivity growth, firms should expand their scale of operation, thereby reducing unit costs forever. This is impossible, as scale economies would be reduced as new firms enter the market and per-firm output falls. Non-technological effects would, however, operate over the short run and would therefore be part of the cyclical component of the Solow residual.

[12] Basu and Kimball (1997) show that if the sole cost of changing the workweek of capital is that workers need to be compensated for working at night, then one can use a single proxy for changes in *both* effort and capital utilization.

$$\tilde{a} \equiv (a+c) = a^{*} + a^{c},$$
$$l = l^{*} + l^{c}, \qquad (17)$$
$$k = k^{*}.$$

The log of total hours (*l*), in turn, can be additively decomposed into its determinants, e.g., working-age population (*wpop*), participation ratio (*pr*), the unemployment rate (*u*), and the average number of hours per employee (*h*).[13] These determinants can be also disentangled into their own permanent and cyclical components, so that the permanent and cyclical labor contributions can be written as:

$$l^{*} = wpop + pr^{*} - u^{*} + h^{*},$$
$$l^{c} = pr^{c} - u^{c} + h^{c}. \qquad (18)$$

The intuition is that population dynamics are fully permanent, whereas labor force participation, employment, and average working hours contain also cyclical information.

Combining identities (16)-(17)-(18) yields a multivariate UC model for output decomposition. Specifically, the model consists of a measurement equation for real output:

$$y_t = \beta wpop_t + (1-\beta)k_t + \begin{bmatrix}1 & \beta & -\beta & \beta\end{bmatrix}\boldsymbol{\mu}_t + \begin{bmatrix}1 & \beta & -\beta & \beta\end{bmatrix}\boldsymbol{\psi}_t, \qquad (19)$$

where the unobserved permanent and transitory components are denoted by $\boldsymbol{\mu}_t = \begin{bmatrix}a^{*} & pr^{*} & u^{*} & h^{*}\end{bmatrix}'$ and $\boldsymbol{\psi}_t = \begin{bmatrix}a^{c} & pr^{c} & u^{c} & h^{c}\end{bmatrix}'$, respectively. The transition system describing the dynamics of such stochastic unobserved components is given by:

$$\begin{cases} \boldsymbol{\mu}_t = \boldsymbol{\mu}_{t-1} + \boldsymbol{\kappa}_{t-1} + \mathbf{v}_t^{\mu}, & \mathbf{v}_t^{\boldsymbol{\mu}} \sim \mathbf{N}(\mathbf{0}, \boldsymbol{\Sigma}_{v^{\mu}}), \\ \boldsymbol{\kappa}_t = (\mathbf{I}-\mathbf{P})\boldsymbol{\kappa}^{*} + \mathbf{P}\boldsymbol{\kappa}_{t-1} + \boldsymbol{\omega}_t^{\kappa}, & \boldsymbol{\omega}_t^{\boldsymbol{\kappa}} \sim \mathbf{N}(\mathbf{0}, \boldsymbol{\Sigma}_{\omega^{\kappa}}), \\ \boldsymbol{\psi}_t = \boldsymbol{\tau}\varphi(L)ip_t + \boldsymbol{\varepsilon}_t^{\boldsymbol{\psi}}, & \boldsymbol{\varepsilon}_t^{\boldsymbol{\psi}} \sim \mathbf{N}(\mathbf{0}, \boldsymbol{\Sigma}_{\varepsilon^{\psi}}). \end{cases} \qquad (20)$$

where the reference cycle—an autoregressive process of second order $\varphi(L)$ that is here constrained to be common across factor inputs—is assumed to be driven by fluctuations in the industrial production index, *ip*. The four transitory components in vector $\boldsymbol{\psi}_t$—e.g., the Solow residual, a^c, the participation ratio, pr^c, the unemployment rate, u^c, and the average hours, h^c—can in turn be expressed as linear combinations of current and lagged values of the reference cycle, given the matrix of loading parameters, τ. Corresponding factor inputs

[13] To maintain log-linearity, while enabling modeling the NAIRU, we use the first-order Taylor approximation for the employment rate, so that $e_t = \ln(1-u_t) \approx -u_t$.

trends—denoted by vector $\boldsymbol{\mu}_t$—are assumed to follow random walk processes with stochastic drifts—denoted by vector $\boldsymbol{\kappa}_t$. The growth rate of each factor trend can thus take a different shape, depending on the value of the corresponding element in the matrix *P*. For instance, if the first element in *P* is estimated to be insignificantly different from 1, then TFP would be an integrated series of second order. Else, if $0<P_{1,1}<1$, the time-varying TFP growth rate would converge back to a steady-state rate, κ_1^*. $\boldsymbol{\varepsilon}_t^{\boldsymbol{\psi}}, \mathbf{v}_t^{\boldsymbol{\mu}}$, and $\boldsymbol{\omega}_t^{\boldsymbol{\kappa}}$ denote the vectors of shocks to the cyclical components, the factor trends, and the trend growth rates, respectively. The shocks are assumed to follow independent identically distributed processes, with error covariance matrices $\boldsymbol{\Sigma}_{\boldsymbol{\varepsilon}}, \boldsymbol{\Sigma}_{\mathbf{v}}$, and $\boldsymbol{\Sigma}_{\boldsymbol{\omega}}$, respectively. The dynamics of permanent and transitory components depend on the nature of the shocks, that is, on the relative importance of supply and demand shocks.[14] This relative importance, which determines the smoothness of the trend component, is the ratio of the variance of the cycle to the variance of the trend fluctuations. A small ratio implies that shocks are mainly supply shocks, where trend inputs moves nearly with observed data, and hence a small business cycle component is to be expected. On the contrary, a larger weight on the smoothness of the trend means that shocks to the economy are primarily shocks to aggregate demand.

Once the model (19)-(20) is cast in the state space form, the Kalman filter and the associated smoothing algorithm enable maximum likelihood estimation of the model parameters and signal extraction of the unobserved components, conditional upon a set of initial parameters and the appropriate information set. More specifically, the *basic filter* provides an estimate of the unobserved state vector conditional upon the information available up to time t. The smoothing provides a more accurate estimate on the vector, by using all the available information in the sample through time T. Under the assumptions of model linearity and Gaussian disturbances, the *conditional distribution* of the observed variables—e.g., real GDP and unemployment—is also Gaussian. As such, the sample log-likelihood function can be maximized with respect to the unknown parameters of the model and the set of parameters can be estimated using a maximum-likelihood estimator. Iterating the basic filter starting from t=1 to *T*, while evaluating the log likelihood function from observation τ+1 (where τ is large enough) to *T,* minimizes the effects of some arbitrarily chosen initial values on the log-likelihood value. On the other hand, the last iteration of the basic filter provides the initial values for the smoothing.[15]

[14] By construction, demand and supply shocks are assumed to be orthogonal.
[15] For a thorough exposition of the state space methodology, the reader may refer to Harvey (1989) and Kim and Nelson (1999). Estimation was carried out in Gauss 6.0.