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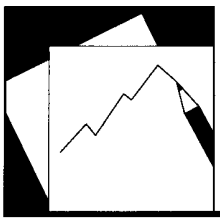

IMF Working Paper

Growth and Inflation Dispersions in EMU: Reasons, the Role of Adjustment Channels, and Policy Implications

Emil Stavrev

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Growth and Inflation Dispersions in EMU: Reasons, the Role of Adjustment Channels, and Policy Implications

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Abstract

This paper's analysis of growth and inflation dispersions in the euro area reveals several findings. First, these dispersions have declined appreciably since EMU; remaining dispersions are small but persistent, relating mainly to country-specific shocks, not differences in the transmission of common shocks. Second, the different behavior of interest rates just before and after the introduction of the euro has contributed significantly to growth dispersions. However, this has been a one-off shock whose effects, particularly on construction, should be declining over time. Third, financial sector integration could do much more to insure countries against shocks and increase consumption smoothing.

JEL Classification Numbers: C3, C33, E31, F15, F2, F36

Keywords: Common and country-specific shocks, output and inflation dispersions, convergence, risks sharing

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I. INTRODUCTION

Growth and inflation dispersions in the euro area have declined since 1990 and are now comparable to those among US states, but they are longer-lasting. As business cycles have become more synchronized after euro adoption, the contribution of the cyclical component to growth dispersions has declined. However, the contribution of the trend component has increased, partly as a result of different degrees of structural reform implementation among euro-area members (Figure 1). The persistence of remaining inflation dispersions has come with cost dispersions and diverging external positions (Figure 2). While temporary differences in inflation dynamics in a monetary union can be benign, e.g., reflecting income convergence or adjustment to country-specific shocks, they can also be associated with risks for future growth and incomes.

Accordingly, growth and inflation dispersions among euro-area countries have attracted attention. Several questions arise from a policy standpoint. In particular, what factors are behind growth and inflation dispersions? What has been the role of the real exchange rate, the real interest rate, and the financial sector in adjustment? What role could further financial integration play in insuring against country-specific shocks that trigger dispersions?

The paper proposes to study these questions by using a variety of distinct approaches. First, the paper examines the contribution of country-specific versus asymmetrically transmitted common shocks in explaining divergences. Second, it studies the role of convergence factors in growth and inflation heterogeneity in the European Monetary Union (EMU). Third, it assesses the role of the interest rate and the housing sector in the adjustment process before and after euro introduction, using Bayesian techniques to fit a small theoretically founded model to the data. Finally, the paper analyzes the contribution of the financial system in sharing country-specific risks, by smoothing consumption and income across euro-area countries.

The analysis reveals several findings. First, growth and inflation dispersions have declined appreciably since the onset of EMU; remaining dispersions are small but persistent, relating mainly to country-specific shocks, not differences in the transmission of common shocks. Second, the different behavior of interest rates just before and after the introduction of the euro has contributed significantly to growth dispersions. However, this has been a one-off shock whose effects are declining over time. Third, and related to the interest rates shock, the construction sector has contributed to growth dispersions. Fourth, financial sector integration could do much more to insure countries against shocks and increase consumption smoothing.

The rest of the paper is organized as follows. Section II provides an overview of the findings in the literature. Section III describes the methodological approaches used in the analysis and discusses the results, while Section IV concludes.

II. LITERATURE REVIEW

The literature has analyzed several aspects of the heterogeneity of economic performance in EMU: (i) the degree of cyclical synchronization and the role of idiosyncratic versus asymmetric propagation of common shocks; (ii) the relative importance of various transmission channels in the adjustment process, notably the role of price and wage rigidities for adjustments in competitiveness; (iii) the role of fiscal policy in divergences; and, (iv) the role of the financial sector in promoting economic convergence and improving cross-country risks sharing and consumption and income smoothing has also featured extensively.

The literature finds that cycles have become more synchronized after the launch of EMU. In particular, Giannone and Reichlin (2006) find that business cycles are similar across EMU countries and movements in outputs are mainly explained by common shocks with similar propagation mechanisms, while idiosyncratic shocks are relatively small but persistent and account for the bulk euro-area dispersions. They also note that shock propagation is more persistent in the euro area than in the United States, but that cycles are less volatile. Eickmeir (2006) also finds that, in general, output and inflation responses to common shocks (demand, supply, monetary policy, and external) across euro-area countries are similar, but long-lasting idiosyncratic shocks are responsible for output and inflation variations across countries. EC (2006) finds that country-specific shocks, including a fall in risk premia following the introduction of the euro, relaxation of credit constraints, and productivity in traded and non-traded goods are important explanatory factors for divergences.

However, despite similarities in the transmission of shocks, differences remain. For example, van den Noord (2004) finds that the decline in the interest rates after the launch of the euro had a different impact on the housing markets in the small and large countries and, via this channel, the shock has had a different effect on economic activity in the two groups. Also, Hoeller and others (2004) argue that, as the cyclical position of housing prices in the small countries may be out of line with the common monetary policy, the construction sector raises dispersions via its impact on activity.

The results in the literature suggest that the competitiveness channel dominates the adjustment process in the medium run, but operates slowly. EC (2006) finds that the procyclical effect of the real interest channel has been somewhat less important than previously thought and dominates in the initial phase of the expansion, while in the medium term adjustments in competitiveness are more important. The study also finds that wage and price rigidities influence the efficiency of the adjustment process and could lead to slow correction in competitiveness and result in protracted economic divergences.

The literature concludes that fiscal policy has contributed to the reduction of output volatility over time, but elements of procyclicality remain. Darvas and others (2005) find evidence that fiscal convergence (persistently similar GDP ratios of government balances) is associated with synchronization of business cycles. They also observe that the Maastricht fiscal criterion may have moved the EMU closer to an optimal currency area by reducing countries' scope to cause idiosyncratic shocks. Darvas and others recognize that by imposing convergence of budget deficits, the criterion could make fiscal policy less effective in counteracting

asymmetric shocks, but the results suggest that the synchronization effect of fiscal policy has dominated.

The literature finds that risk sharing has increased over the past decade, but the share of idiosyncratic shocks smoothed by the financial system is significantly lower in the EMU than in the United States. In particular, Kalemli-Ozcan, Sørensen, and Yosha (2004) find that about 10 percent of idiosyncratic (country-specific) shocks to the per capita gross domestic product of the euro area countries (over 1993-2000) are smoothed through capital markets, while 55 percent are in the United States (over 1991-1998). Marinheiro (2003) estimates a somewhat higher share of smoothed country-specific shocks for the euro area (25 percent) but still significantly lower than in the United States. He also finds that if financial system integration in the euro area reaches the level of the United States, its contribution to smoothing idiosyncratic shocks could increase by about 20 percentage points.

III. Analytical Framework and Estimation Results

A. Common versus country-specific shocks

The relative importance of common and country-specific shocks for inflation and growth was estimated using a bi-variate VAR for each country. Specifically, two separate bi-variate VARs were estimated for each country—one for inflation and one for growth:

$$\begin{bmatrix} \bar{x}_t \\ x_t^i \end{bmatrix} = A_1 \begin{bmatrix} \bar{x}_{t-1} \\ x_{t-1}^i \end{bmatrix} + A_2 \begin{bmatrix} \bar{x}_{t-2} \\ x_{t-2}^i \end{bmatrix} + A_3 \begin{bmatrix} \bar{\varepsilon}_t \\ \varepsilon_t^i \end{bmatrix},$$

where $\bar{x}_t$ is the euro area growth/inflation, x_t^i is country *i* growth/inflation, $\bar{\varepsilon}_t$ is a common shock, and ε_t^i is a country-specific shock. The VARs were estimated with quarterly data for two periods—pre-EMU (1980Q1-1998Q4) and EMU (1999Q1-2006Q4). To identify the structural shocks, the euro area growth/inflation were assumed to be affected by country-specific shocks with a lag.

The impact of common and country-specific shocks on growth and inflation was calculated using the estimated impulse response functions from the above VARs. The above systems can be rewritten in terms of the impulse response functions and the structural shocks, as follows:

$$\begin{bmatrix} \bar{x}_t \\ x_t^i \end{bmatrix} \approx \sum_j^{\infty} \begin{bmatrix} \phi_{11}(j) & \phi_{12}(j) \\ \phi_{21}(j) & \phi_{22}(j) \end{bmatrix} \begin{bmatrix} \bar{\varepsilon}_{t-j} \\ \varepsilon_{t-j}^i \end{bmatrix},$$

where $\phi_{11}(j)$ is the impulse response function of euro area growth/inflation to common shocks, $\phi_{21}(j)$ is the impulse response function of growth/inflation in each country to common shocks, $\phi_{12}(j)$ is the impulse response of euro area growth/inflation with respect to

country-specific shocks, and $\phi_{22}(j)$ are the impulse response functions of growth and inflation in each country with respect to country-specific shocks.

The main findings from the estimation results point to significantly more euro-area member country integration since the start of the currency union. The contribution of common shocks to inflation and growth has increased since the introduction of the euro (Figure 3). While, on average common shocks accounted for 20 percent growth and 30 percent of inflation before EMU creation, their contribution increased to around 60 percent for both growth and inflation during EMU. Also, common shocks trigger increasingly similar responses across member countries.

Next, using the above decomposition of the shocks, the contribution of country-specific shocks to growth/inflation dispersions is related to the estimated impulse response functions as follows:

$$\frac{[\phi_{22}(j)-\phi_{12}(j)]^2}{[\phi_{22}(j)-\phi_{12}(j)]^2+[\phi_{21}(j)-\phi_{11}(j)]^2}.$$

This relationship was used to calculate how much of the dispersions is due to country specific shocks. Remaining growth and inflation dispersions have largely been driven by country-specific shocks since the euro introduction, not different country responses to common shocks. Country-specific shocks account for more than 70 percent of *growth dispersions* (with the exception of Austria, 45 percent, and Greece, 40 percent, Figure 4) and more than 75 percent of *inflation dispersions* (except Italy, 40 percent, Figure 5).

B. Country-specific developments and income and price level convergence

The impact of income and price level convergence on growth and inflation dispersions is assessed using two panel regressions:

- For *inflation dispersions*, $\pi_{i,t}-\pi_t^{EA}=\alpha+\gamma\log(P_{i,t0}/P_{t0}^{EA})+\varepsilon_{i,t}$, where $\pi_{i,t}-\pi_t^{EA}$ is the deviation of inflation in each country from the euro-area average and $\log(P_{i,t0}/P_{t0}^{EA})$ is the deviation of the price level in a member country from the euro area average at the beginning of the sample.

- For *growth dispersions*: $g_{i,t}-g_t^{EA}=\alpha+\gamma\log(YP_{i,t0}/YP_{t0}^{EA})+\varepsilon_{i,t}$, where $g_{i,t}-g_t^{EA}$ is the deviation of output growth in each country from the euro-area average and $\log(YP_{i,t0}/YP_{t0}^{EA})$ measures the percent difference of member countries' per capita GDP from the euro-area average at the beginning of the sample. The above equations were estimated for two periods: pre-EMU (1980-1998) and EMU (1999-2006).

The estimation results suggest an increasing importance of income convergence and a declining role of price level convergence in accounting for dispersions over time. Price level convergence was associated with 60 percent of inflation dispersions during 1980-1998 but this halved under EMU (to slightly above 30 percent of inflation dispersions). Findings elsewhere in the literature suggest similar results. For example, Rogers (2007) concludes that the price levels of traded goods in EMU have converged mostly prior to the euro adoption, with their dispersion thereafter similar to that in the United States. At the same time, income convergence accelerated under EMU and accounted for a larger share of growth dispersions compared to the pre-EMU period. However, from a policy standpoint it is important to bear in mind that "accounting for" does not mean "causing". Accordingly, temporary rather than fundamental convergence factors could also explain the remaining growth and inflation dispersions.

Income and Price Level Convergence and Dispersions 1/

		1980-1998		1999-2006	
		Inflation	Growth	Inflation	Growth
Speed of convergence,	γ	-0.47	-0.11	-0.42	-0.25
Adjusted R^2		0.60	0.01	0.31	0.12

1/ Impact of 10 percent price/income level difference from euro area average on inflation/growth dispersions, in percentage points.

C. Persistence of country-specific developments

Persistence of remaining growth and inflation dispersions is estimated using the following panel regression:

$$x_{i,t} - x_t^{EA} = \alpha + \rho\,(x_{i,t-1} - x_{t-1}^{EA}) + \gamma \log(X_{i,t-1} / X_{t-1}^{EA}) + \varepsilon_{i,t}\,,$$

where $x_{i,t} - x_t^{EA}$ is the deviation of inflation/growth in each country from the euro area average and $\log(X_{i,t-1} / X_{t-1}^{EA})$ is the deviation of the price level/PPP GDP per capita in a member country from the euro area average. The coefficient γ in the above equations captures the persistence of dispersions, with a lower value of the coefficient in absolute terms corresponding to slower adjustment.

The estimation results imply that persistence of inflation and growth dispersions has increased under EMU. Although the above framework does not identify the sources of persistence in inflation and growth dispersions, aside from convergence factors, another reason could be different degrees of structural reforms among euro-area members during EMU. In

Persistence of Inflation and Growth Dispersions 1/

		1980-1995		1996-2006	
		Inflation	Growth	Inflation	Growth
		With lagged dependent variable			
Short-term,	γ	-0.5	-0.9	-0.2	-0.4
Long-term,	$\frac{\gamma}{1-\rho}$	-1.3	-1.4	-0.4	-0.5
Adjusted R^2		0.9	0.3	0.8	0.6

1/ Lower coefficient in absolute terms means higher persistence.

particular, ECB (2005) finds that services prices and differences in wage developments have been major sources of inflation persistence, and the degree of structural reform in both services sectors and labor markets has differed noticeably among euro-area members over the past decade.

D. Shock transmission and relative importance of channels

The relative importance of the transmission channels was studied using a general equilibrium model.[2] Equations (1) – (4) represent the core of the model.

$$y_t = \beta_1 y_{t-1} + \beta_2 y_{t+1} + \beta_3 hg_{t-1} + \beta_4 rg_{t-1} + \beta_5 zg_{t-1} + \beta_6 \hat{y} + \varepsilon_t^y \quad (1)$$

where, y_t is output gap, hg_t is real house prices gap, rg_t is real interest rate gap, zg_t is real exchange rate gap, and $\hat{y}$ stands for the current period euro area output gap in a country model/the lagged output gap of a country in the euro area model. Potential output, equilibrium interest rate, equilibrium real exchange rate, and equilibrium real house prices are also defined in the model, which allows consistent estimates of the gaps within the model (for full model specification see the Appendix).

$$\pi_t = \alpha_1 \pi_{t-1} + (1-\alpha_1)\pi_{t+1} + \alpha_2 y_{t-1} + \alpha_3 \Delta z_t + \alpha_4 \hat{\pi} + \varepsilon_t^\pi \quad (2)$$

where, π_t is inflation, z_t is logarithm of real exchange rate, $\hat{\pi}$ denotes the current period euro area inflation in a country model/the lagged inflation of a country in the euro area model, and Δ is first difference operator.

$$hg_t = \rho_1 hg_{t-1} + \gamma_1 rg_{t-1} + \varepsilon_t^{hg} \quad (3)$$

where, hg_t is real house prices gap.

$$rs_t = \delta_1 rs_{t-1} + (1-\delta_1)[re_{t-1} + \pi_t + \delta_2(\pi_{t+1} - \overline{\pi}) + \delta_3 y_t] + \varepsilon_t^{rs} \quad (4)$$

where, rs_t is nominal interest rate, re_t is real equilibrium interest rate, and $\overline{\pi}$ is inflation target.

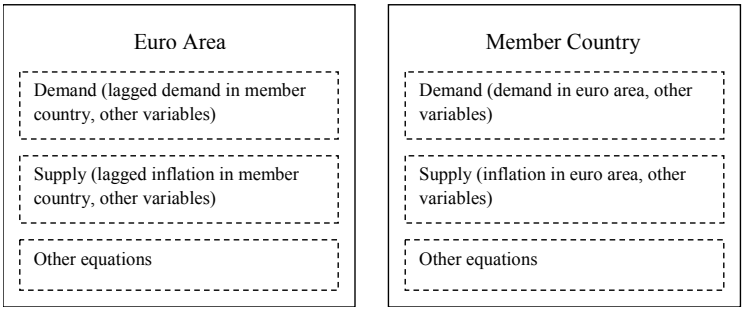
Equation (1) is an aggregate demand function, which has a lagged term to capture persistence in the data and a forward looking component as in Gali and Gertler (1999). Aggregate demand depends also on the real interest rate gap, capturing the interest rate channel, the real

[2] The model was estimated using Bayesian techniques for Austria, France, Germany, Italy, Netherlands, Portugal, Spain, and the euro area (weighted average of the sample countries) over three periods: (i) the full sample, 1980-2006; (ii) pre-EMU period, 1980-1995; and (iii) EMU period, 1996-2006. While formally the above countries renounced their monetary policy in 1999, the interest rates have converged and exchange rate was not used as a policy tool since 1996. Hence, for estimation purpose the EMU period starts in 1996.

house price gap, reflecting cyclical effects from asset prices on aggregate demand, external demand.

Equation (2) is a standard open economy Phillips curve in which inflation is driven by demand conditions, exchange rate developments, and external shocks. Equation (3) defines real house price gap as a function of real interest rates. Real interest rate changes affect house prices by changing the opportunity cost of capital invested in housing, the cost of servicing mortgage credit, and the present value of future household earnings. Finally, equation (4) is a monetary policy reaction function, in which the central bank cares about inflation and output gap.

The impact of various shocks on dispersions was assessed by simulating the estimated models for each country with that for the euro area together. The interaction of area-wide and country-specific shocks takes place through the demand and supply equations in the model of the euro area and that of a member country. Area-wide demand and supply shocks are assumed to affect each country contemporaneously, while country-specific shocks are assumed to affect euro-area demand and inflation with a lag.



The simulations with the estimated models suggest that:

- The EMU-related changes in interest rates have contributed do growth divergences, accounting on average for about 25 percent of them (Figures 6).

- The impact of house prices differs across the countries reviewed and explains about 15 percent of growth dispersions (Figures 7–8).

E. Cross-country consumption and income smoothing

The degree of cross-country risk sharing and the role of the financial system over time was estimated using a panel regression featuring cross-country correlations of GNP/consumption conditional on output. The idea is that absence of correlation between GNP/consumption and output suggests risk sharing, e.g., via credit or capital markets. Thus,

$$\Delta x_{i,t} - \Delta x_t^{EA} = \alpha + \beta_t (\Delta y_{i,t} - \Delta y_t^{EA}) + \varepsilon_{i,t}, \qquad (5)$$

where the deviation of per capita GNP/consumption growth of country *i* from the euro area ($\Delta x_{i,t} - \Delta x_t^{EA}$) is regressed on the deviation of country *i* per capita output growth from the

euro area ($\Delta y_{i,t} - \Delta y_t^{EA}$), and the coefficient β_t measures uninsured risk over time (β_t=0 means perfect risk-sharing). To assess the contribution of the financial system, the time varying coefficient β_t is specified as a function of time and the dispersion of financial development in EMU countries:[3]

$$\beta_t = \beta_0 + \beta_1 t + \beta_2 (F_{i,t} - F_t^{EA}) \tag{6}$$

Substituting (6) into (5) results in:

$$\Delta x_{i,t} - \Delta x_t^{EA} = \alpha + \beta_0 (\Delta y_{i,t} - \Delta y_t^{EA}) + \beta_1 t (\Delta y_{i,t} - \Delta y_t^{EA}) + \beta_2 (F_{i,t} - F_t^{EA})(\Delta y_{i,t} - \Delta y_t^{EA}) + \varepsilon_{i,t} . \tag{7}$$

The coefficient β_0 measures the average uninsured risk, β_1 indicates how risk-sharing evolves over time, and β_2 captures the effect of financial system. A negative β_2 coefficient lowers the degree of co-movement between consumption/GNP with output, reducing the amount of unshared risk. Equations (5) and (8) were estimated for the euro area excluding Ireland and Luxemburg over the period 1980-2006.

The empirical results suggest that the financial system has played a role in income (=GNP) but not in consumption risk sharing.
The coefficient on the interaction of the financial system development with GDP (coefficient β_2) is significant for GNP, but insignificant for consumption. Also, the contribution of the financial system to risks sharing does not seem to have changed significantly over time, as the trend coefficients in both the GNP and consumption equations are insignificant.

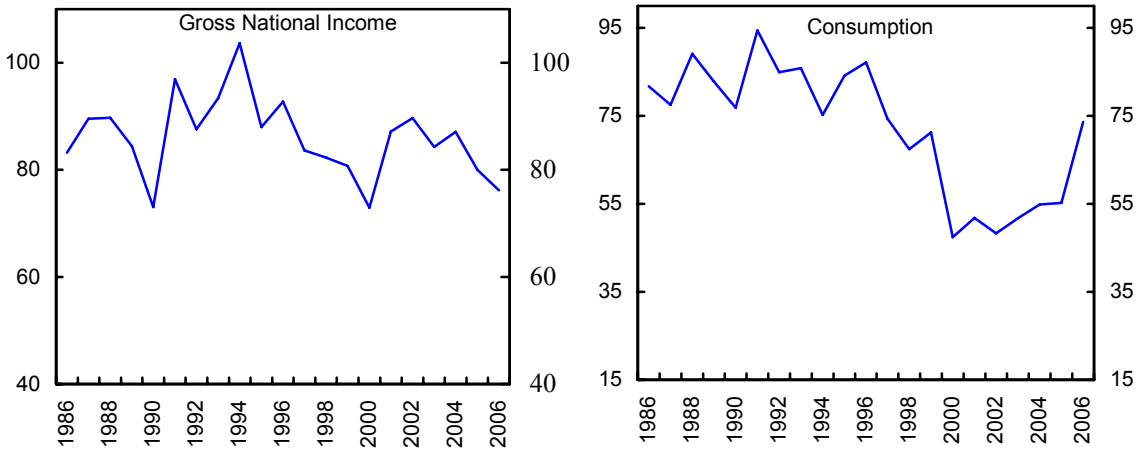
Regression Results 1/

	GNP	Consumption
β_0	0.94	0.70
	(0.13)	(0.23)
β_1	-0.005	0.01
	(0.01)	(0.01)
β_2	-0.96	-0.19
	(0.18)	(0.24)

Standard errors in parentheses. Estimation period 1980-2006.

[3] The GDP share of credit of deposit money banks to the private sector was used as a proxy for financial system development. The advantage of this indicator is that it does not consider credit issued to governments, but a shortcoming is that it captures only the role of the banking system and not of other financial institutions or the securities market. However, given the dominant role of the banks in the euro area, using this indicator may not result in a large bias. In future work the following alternative indicators could be used as a cross-check: (i) liquid liabilities, comprising currency and interest-bearing liabilities of bank and non-bank financial intermediaries; (ii) stock market capitalization; and, (iii) the common component of the three measures from a principle component regression.

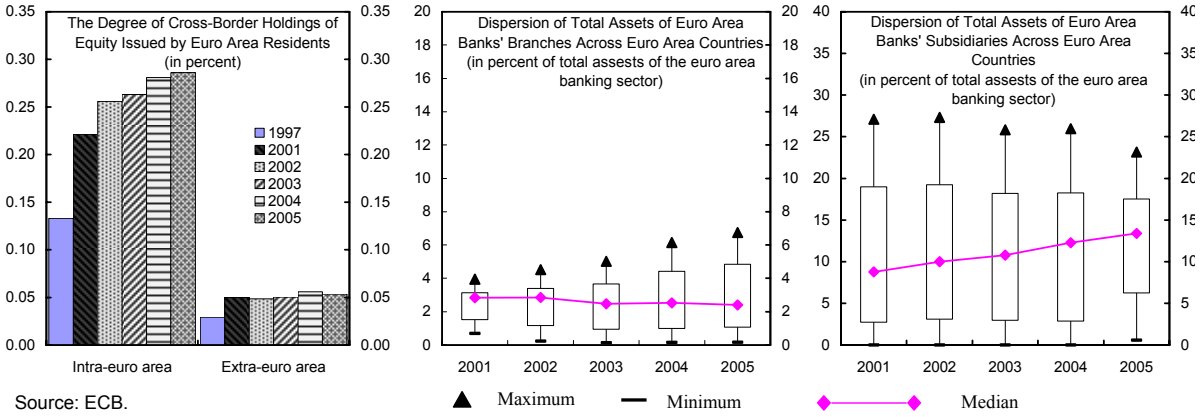
Unshared Risk 1/
(In percent)



1/ 5-year moving average of the coefficient β_t in equation (5).

This finding suggests that risk sharing via financial markets is better developed for investment (which accounts for much of the difference between GNP and consumption) than for household consumption.[4] One reason may be the still limited integration of retail banking in Europe. While the share of cross-border holdings of equities by euro-area residents doubled between 1997 and 2005, the median share of total assets of branches of euro-area banks that are located outside home countries remained practically unchanged at below 3 percent of all euro-area banking assets; the same figure for subsidiaries increased marginally to around 13 percent in 2005, from around 9 percent in 2001 (see ECB, 2007). Overall, it is well known that retail banking is appreciably less well integrated than many other financial activities (among others, see Decressin et al., 2007).

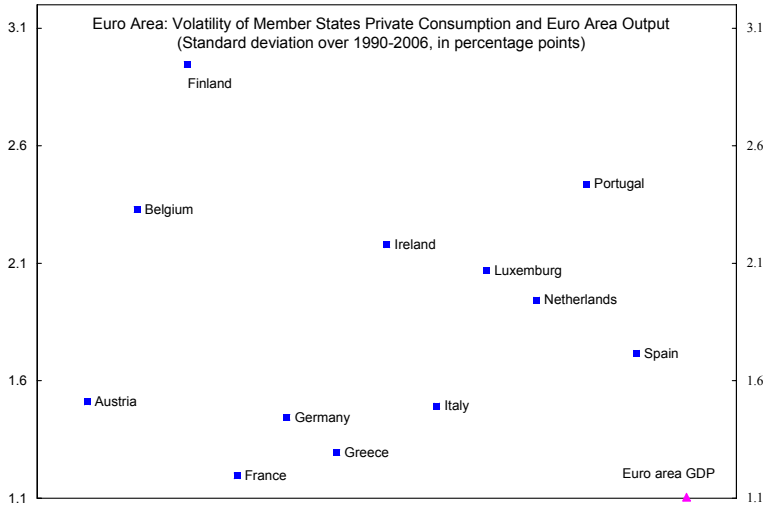
Indicators of Financial Integration



Source: ECB.

[4] Auxiliary regressions confirmed this and are available upon request.

The potential welfare gains from further financial integration among EMU members are substantial for each euro-area country. A comparison of the volatility of the individual euro-area members private consumption growth with the volatility of euro-area output growth suggests a high potential for additional risk sharing. Euro-area output is less volatile than consumption in each member state. Specifically, at 1.1 percentage points, the standard deviation of euro-area output growth is far lower than the maximum standard deviation of private consumption growth of around 3 percentage points and lower than the minimum standard deviation of private consumption growth of 1.2 percentage points.



IV. CONCLUSIONS

Euro-area members share common shocks and their contribution to growth and inflation has increased since EMU but dispersions remain. The results of this paper suggest that inflation and growth in EMU countries are to a large extent driven by common shocks, the importance of which has increased over time. This suggests that the common monetary policy may have contributed significantly to the business-cycle synchronization and stabilization, as might have the better synchronization of fiscal policy. In particular, while common shocks explained around 30 percent of growth and inflation in euro-area members before the introduction of the euro, their contribution increased to around 60 percent after that. At the same time, common shocks increasingly trigger common responses. Accordingly, their contribution to dispersions has declined. This is important not least because it suggests that the potential for monetary policy to efficiently and effectively address common shocks has increased. The remaining dispersions are predominantly driven by country-specific shocks.

Several factors have contributed to the idiosyncratic shocks that drive remaining dispersions. One factor has been income and price level convergence. This factor could account for over 30 percent of the remaining inflation dispersions and has gained importance in growth dispersions under EMU. It will persist but its force will diminish. Another set of factors, which is not necessarily orthogonal to the first one, has been EMU-related changes in the interest rates and house price developments. This can account for 40 percent of growth divergences and may largely be of a one-off nature.

The persistence of idiosyncratic shocks raises the importance of facilitating adjustment to shocks. The functioning of the labor and product markets could be improved to foster a better

operation of the competitiveness channel and higher productivity growth. The latter would facilitate faster adjustment during downturns, given downward nominal wage rigidity. Fiscal policy in the member states could absorb idiosyncratic shocks by allowing automatic stabilizers to work (see Eichengreen and Wyplosz, 1998). Finally, a fully integrated financial system could serve as a powerful insurance mechanism against asymmetric shocks, by allowing relatively stable consumption—funded via private rather than public borrowing and government intervention—despite fluctuations in domestic output.

Further integration of the euro-area financial system could significantly enhance income smoothing and reduce dispersions. While financial sector integration has accelerated, it has not achieved its full potential. For example, as shown in the literature and confirmed in this study, the contribution of the financial sector to income smoothing could be increased significantly—some studies suggest by 20 percentage points or more, if its level of integration reaches that of the United States. Further integration of the European capital markets can play an important role in this respect. In addition, integration of retail banking can also contribute to risk sharing, as the resulting flow of cross-country interest payments will help countries smooth idiosyncratic shocks and incomes, lowering consumption growth dispersions in the euro area.

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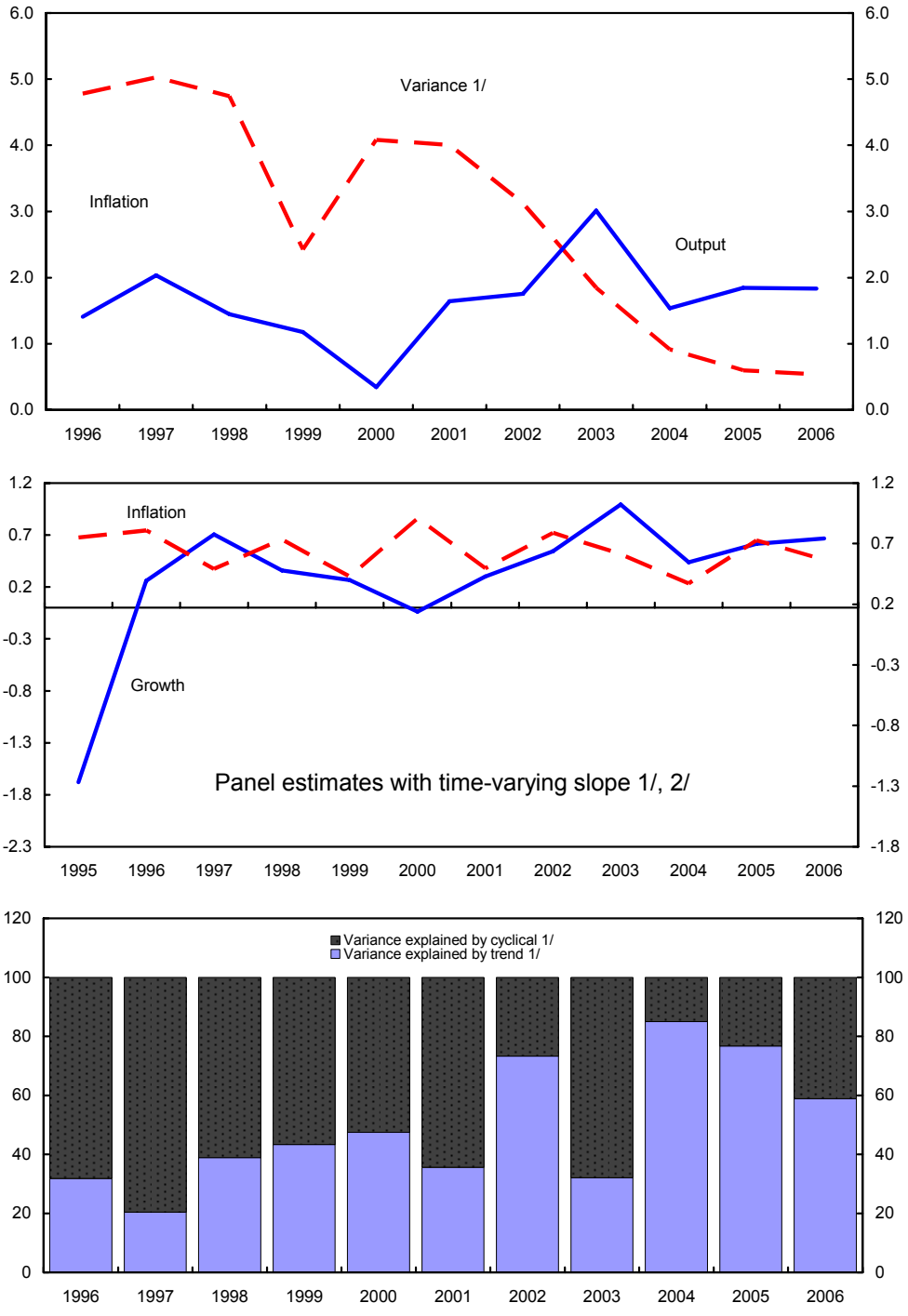
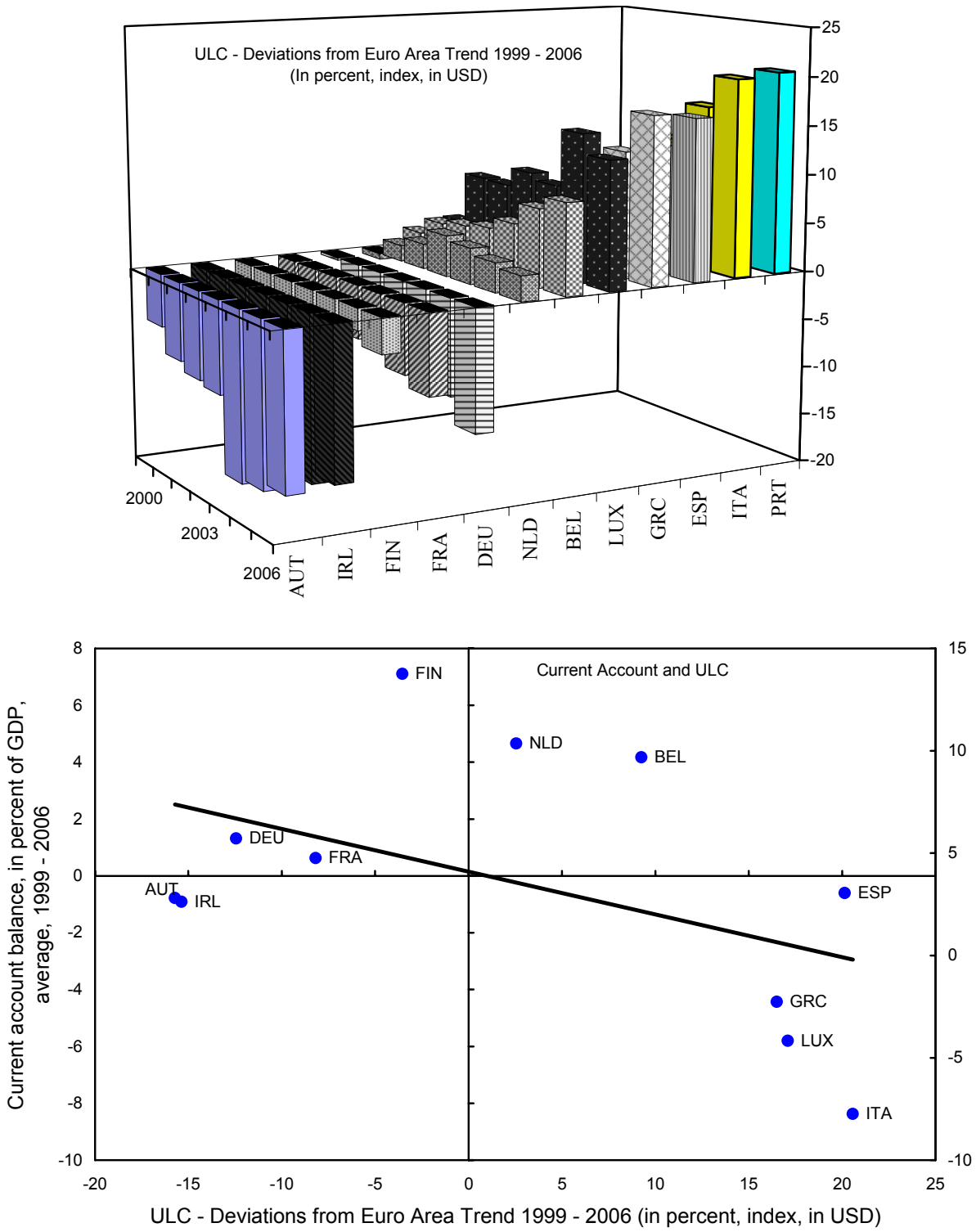
Figure 1. Euro Area: Growth and Inflation Dispersions



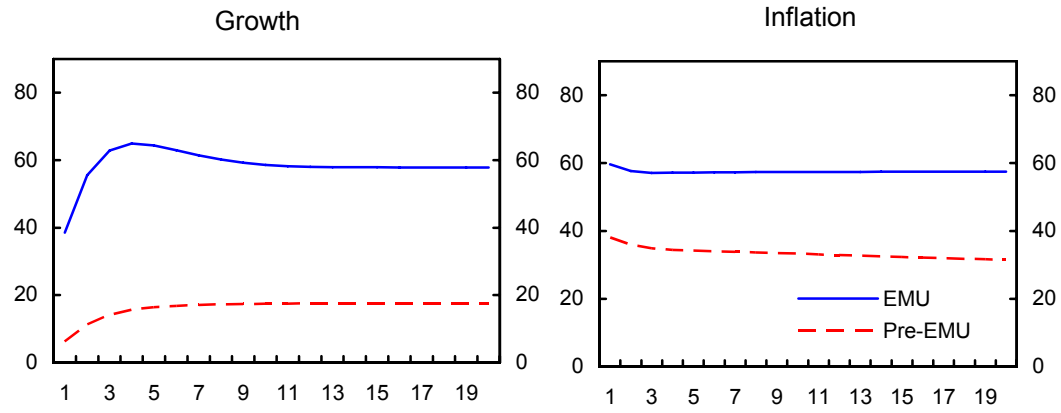
Source: IMF, *World Economic Outlook*.
1/ Excluding Ireland and Luxemburg.
2/ Estimated equation: $x_{t,i} - \bar{x}_t = \alpha_i + \beta_t (x_{t-1,i} - \bar{x}_{t-1}) + \varepsilon_{t,i}$ where $x_{t,i}$-growth/inflation of each member state; $\bar{x}_t$ -Euro area growth/inflation; β_t -persistence parameter.

Figure 2. Euro Area: Unit Labor Costs and Current Account



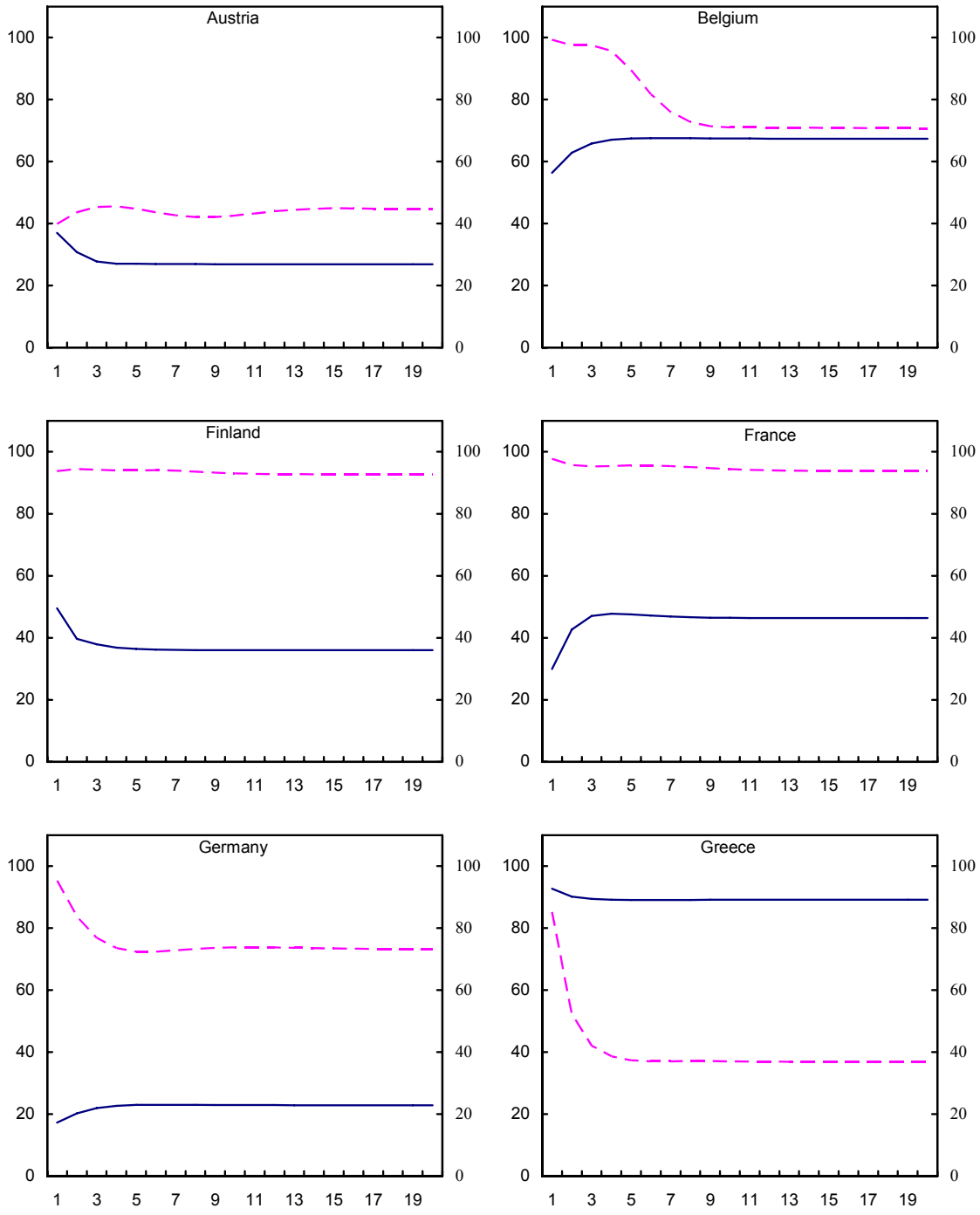
Sources: IFS and WEO database.

Figure 3. Euro Area: Contribution of Common Shocks to Inflation and Growth, Pre-EMU and EMU
(In percent)



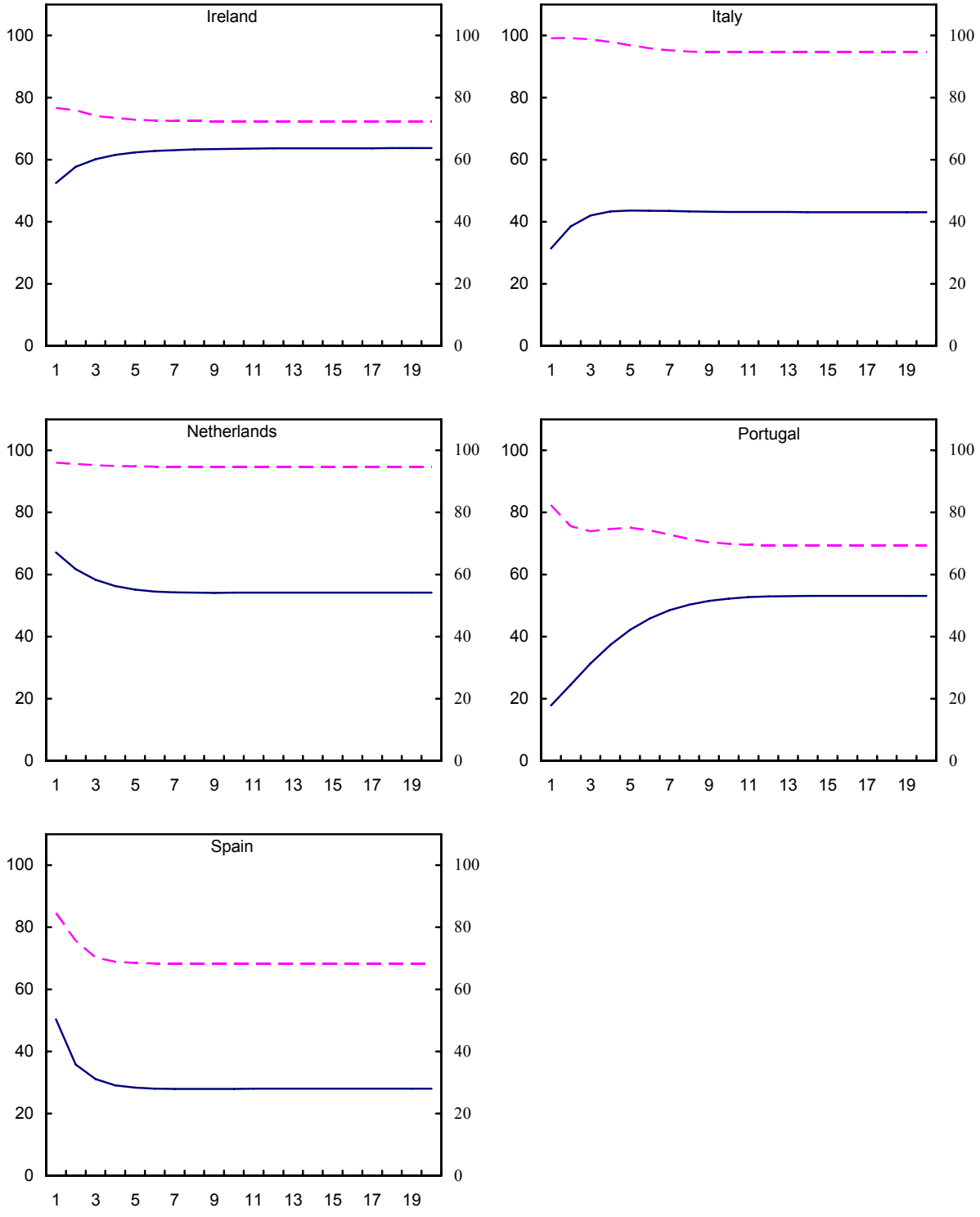
Source: IMF Staff calculations.

Figure 4a. Euro Area: Contribution of Country-specific Shocks to Growth Dispersions, Pre-EMU and EMU
(In percent)



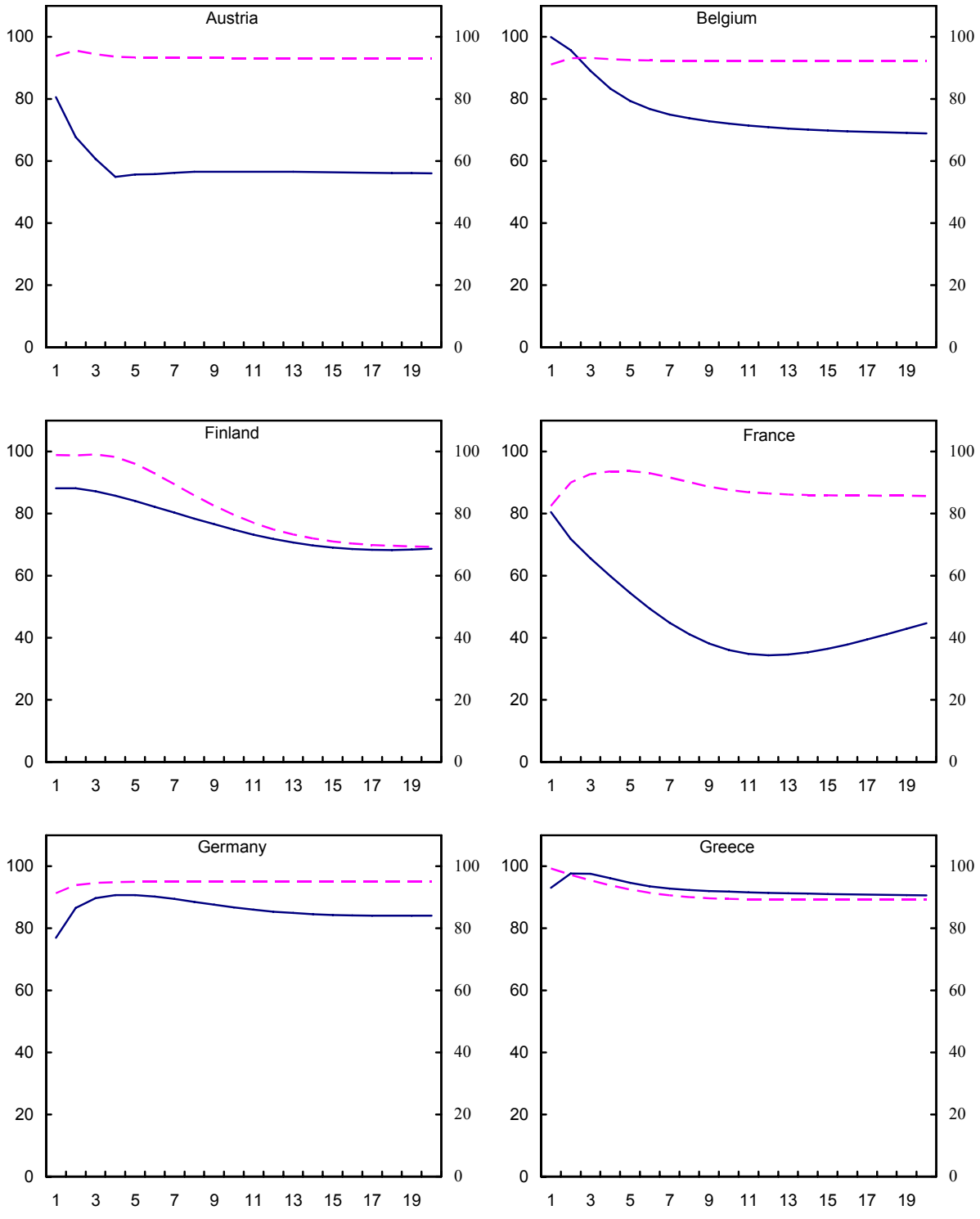
Source: IMF Staff calculations.

Figure 4b. Euro Area: Contribution of Country-specific Shocks to Growth Dispersions, Pre-EMU and EMU (Concluded)
(In percent)



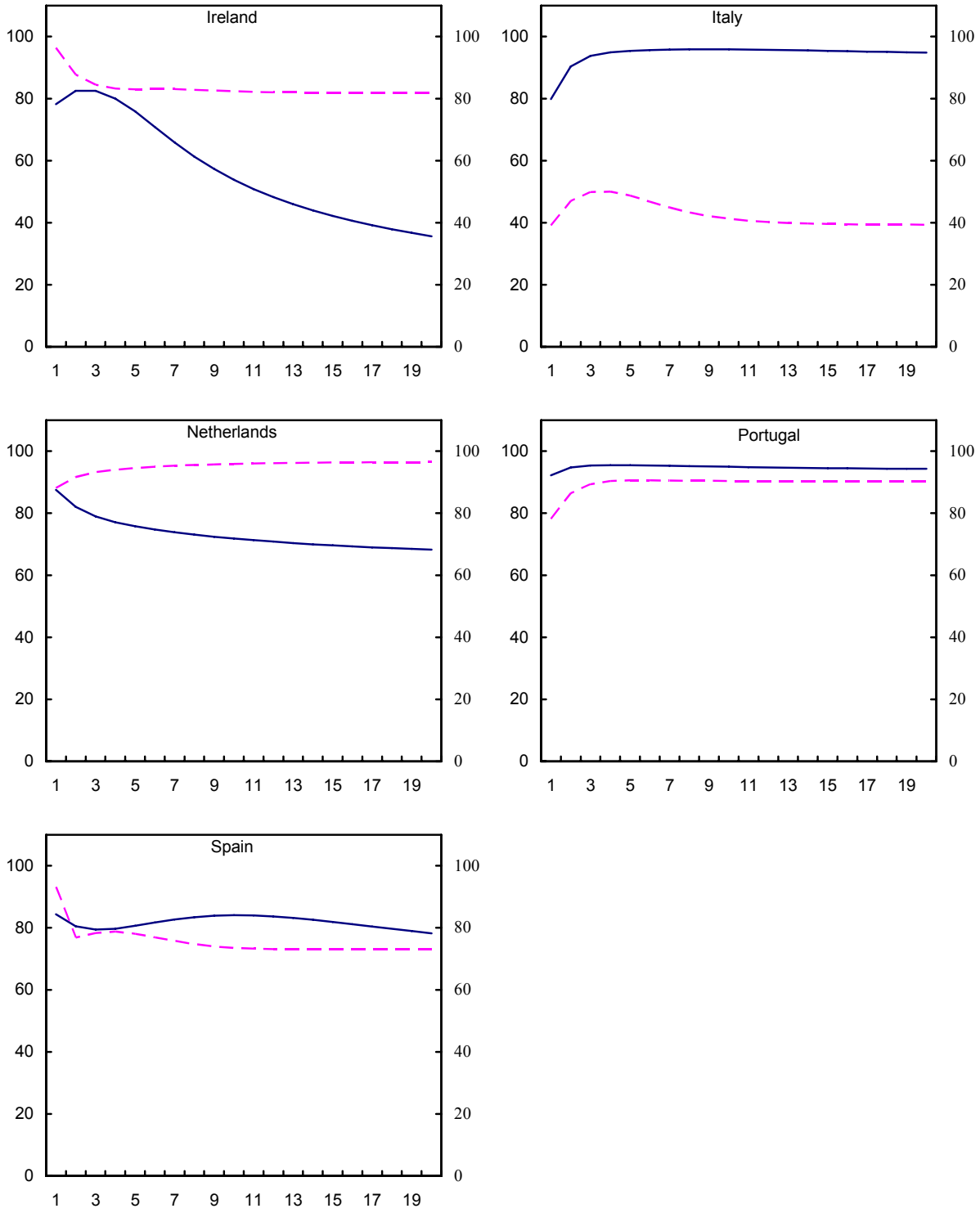
Source: IMF Staff calculations.

Figure 5a. Euro Area: Contribution of Country-specific Shocks to Inflation Dispersions, Pre-EMU and EMU
(In percent)



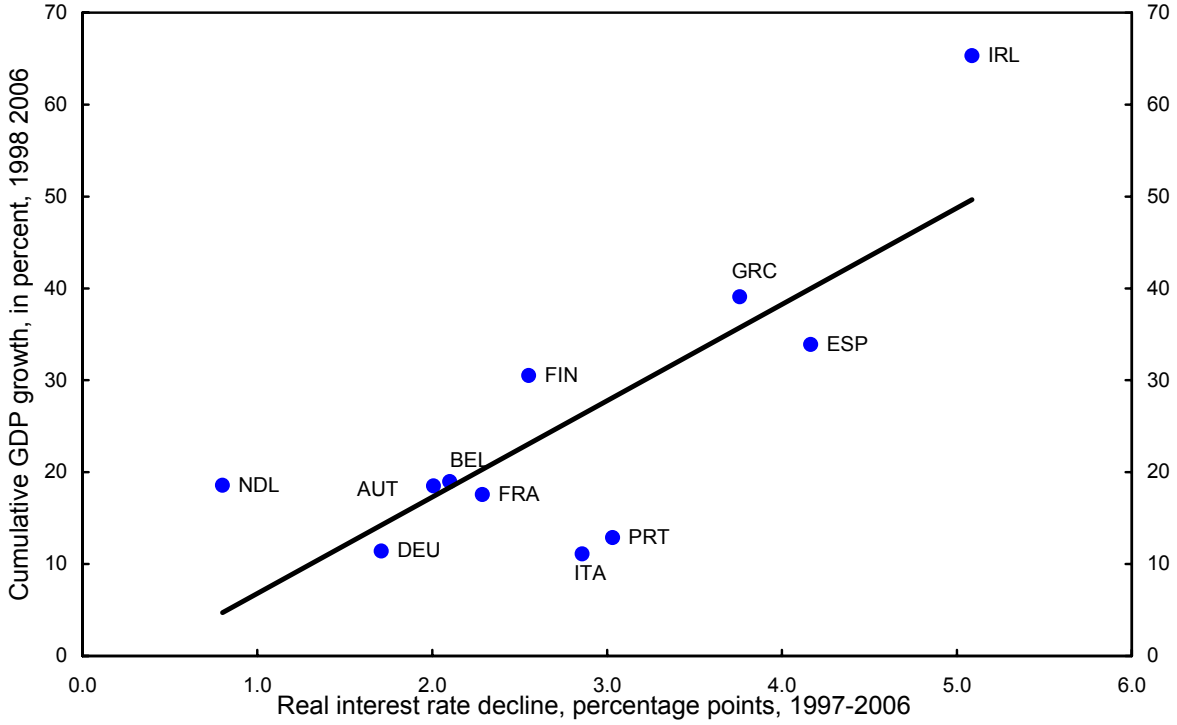
Source: IMF Staff calculations.

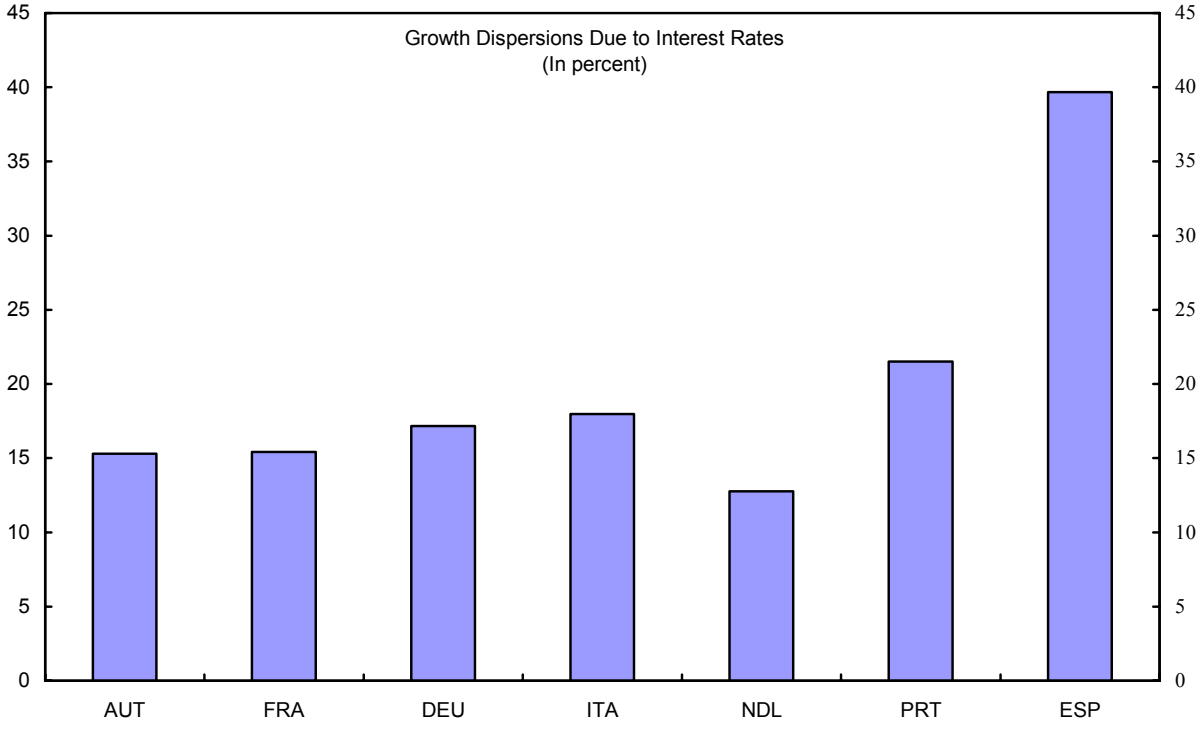
Figure 5b. Euro Area: Contribution of Country-specific Shocks to Inflation Dispersions, Pre-EMU and EMU (Concluded)
(In percent)



Source: IMF Staff calculations.

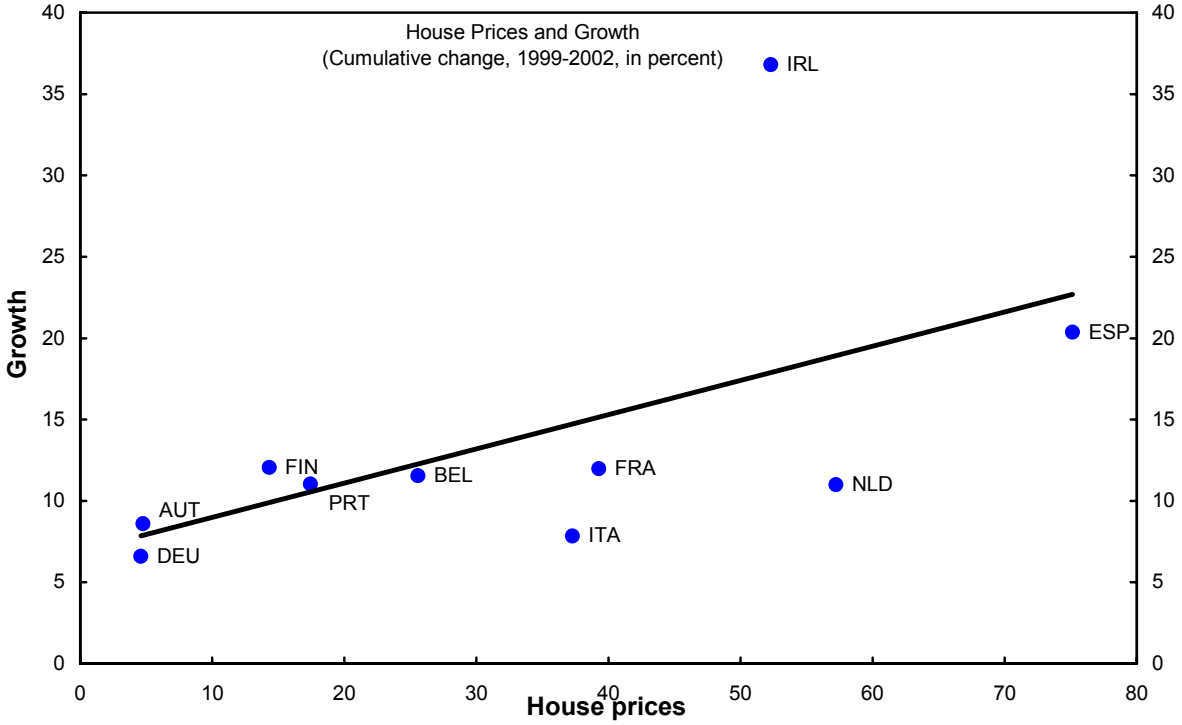
Figure 6. Euro Area: Interest Rates and Growth Dispersions

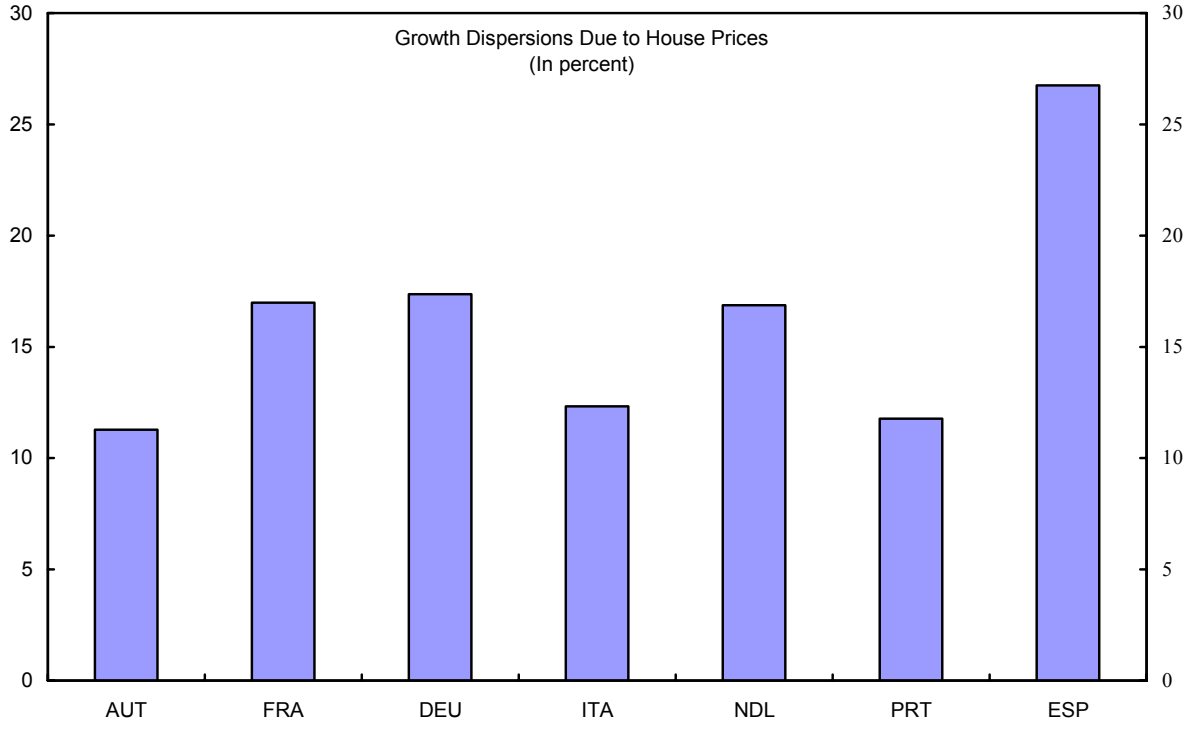




Source: IMF Staff calculations.

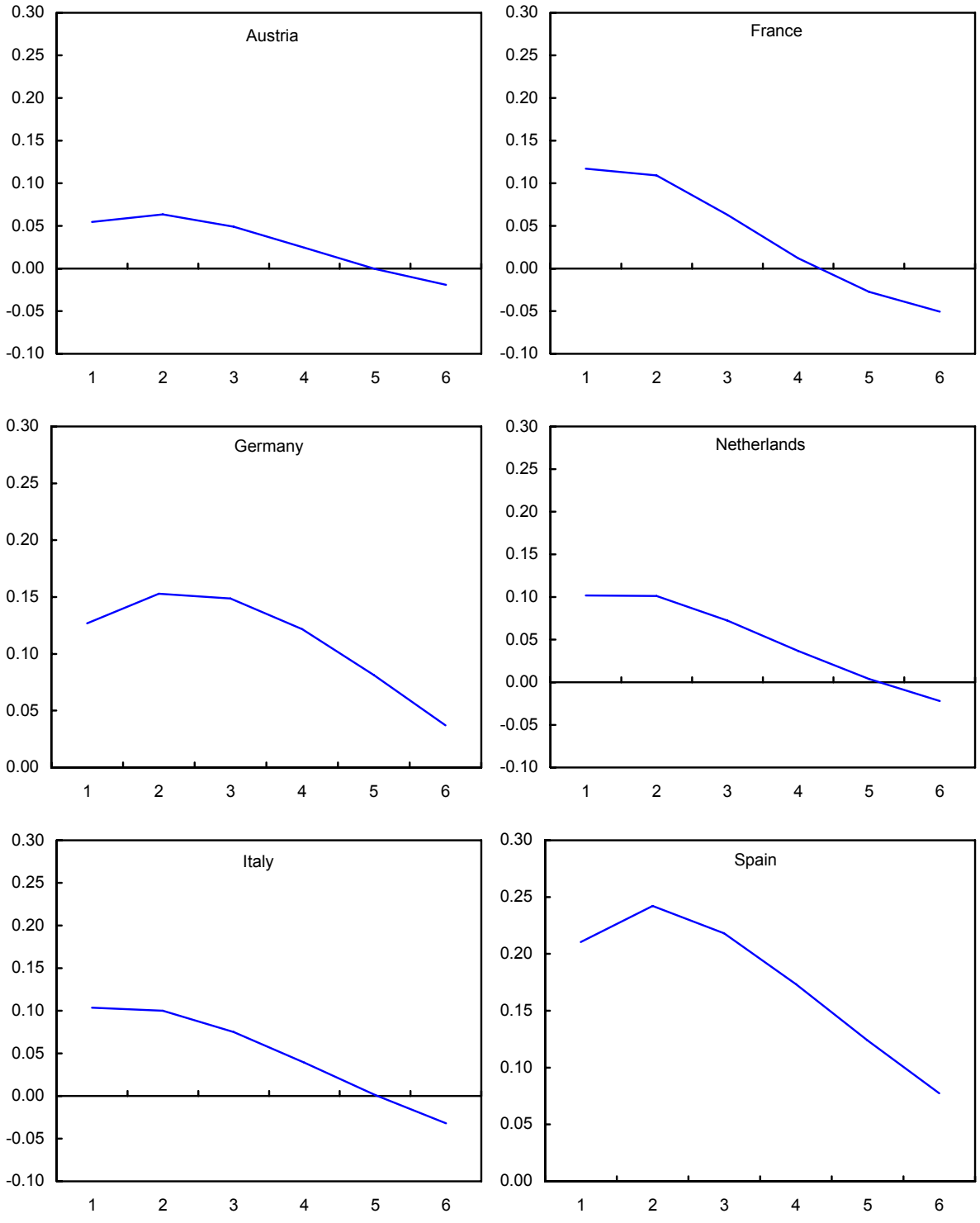
Figure 7. Euro Area: House Prices and Growth Dispersions





Sources: BIS and IMF Staff calculations.

Figure 8. Euro Area: Impulse Response of Output to House Price Shock
(10 percentage points shock to house prices)



Source: Fund staff estimates.

APPENDIX—DYNAMIC GENERAL EQUILIBRIUM MODEL

The model consists of the following equations.

Output

Aggregate demand:

$$y_t = \beta_1 y_{t-1} + \beta_2 y_{t+1} + \beta_3 hg_{t-1} + \beta_4 rg_{t-1} + \beta_5 zg_{t-1} + \beta_6 \hat{y} + \varepsilon_t^y \quad (1)$$

where, y_t is output gap, hg_t is real house prices gap, rg_t is real interest rate gap, zg_t is real exchange rate gap, and $\hat{y}$ stands for the current period euro area output gap in a country model/the lagged output gap of a country in the euro area model.

Potential growth

$$g_t = \lambda g\_s + (1-\lambda) g_{t-1} + \varepsilon_t^g \quad (2)$$

where, g_t is potential growth, and g_s is steady state growth.

Potential output

$$lye_t = lye_{t-1} + g_t + \varepsilon_t^{lye} \quad (3)$$

where, lye_t is logarithm of potential output.

GDP

$$ly_t = lye_t + y_t \quad (4)$$

where, ly_t is logarithm of GDP.

Phillips curve:

$$\pi_t = \alpha_1 \pi_{t-1} + (1-\alpha_1)\pi_{t+1} + \alpha_2 y_{t-1} + \alpha_3 \Delta z_t + \alpha_4 \hat{\pi} + \varepsilon_t^{\pi} \quad (5)$$

where, π_t is inflation, z_t is logarithm of real exchange rate, $\hat{\pi}$ denotes the current period euro area inflation in a country model/the lagged inflation of a country in the euro area model, and Δ is first difference operator.

House prices

Real house price gap

$$hg_t = \rho_1 hg_{t-1} + \gamma_1 rg_{t-1} + \varepsilon_t^{hg} \quad (6)$$

where, hg_t is real house prices gap.

Growth of real house prices

$$gh_t = \tau gh\_s + (1-\tau) gh_{t-1} + \varepsilon_t^{gh} \quad (7)$$

where, gh_t is growth of real house prices, and gh_s is equilibrium growth of real house prices.

Equilibrium real house prices

$$he_t = he_{t-1} + gh_t + \varepsilon_t^{he} \quad (8)$$

where, he_t is logarithm of real equilibrium house prices.

Real house prices

$$h_t = he_t + hg_t \quad (9)$$

where, is logarithm of real house prices.

Exchange rate

Real exchange rate gap

$$zg_t = z_t - ze_t \tag{10}$$

where, zg_t is real exchange rate gap, z_t is logarithm of the real exchange rate, and ze_t is logarithm of real equilibrium exchange rate.

Equilibrium real exchange rate

$$ze_t = ze_{t-1} + \varepsilon_t^{ze} \tag{11}$$

Uncovered Interest Parity

$$z_t = z_{t+1} + (r_t - rf_t) + \varepsilon_t^{z} \tag{12}$$

where, r_t is domestic interest rate, and rf_t is foreign interest rate.

Interest rates

Real interest rate

$$r_t = rs_t - \pi_{t+1} \tag{13}$$

where, r_t is real interest rate, and rs_t is nominal interest rate.

Equilibrium real interest rate

$$re_t = \vartheta re\_s + (1-\vartheta) re_{t-1} + \varepsilon_t^{re} \tag{14}$$

Where, re_t is real equilibrium interest rate, and re_s is steady state real interest rate.

Real interest rate gap

$$rg_t = r_t - re_t + \varepsilon_t^{rg} \tag{15}$$

Monetary policy reaction function

$$rs_t = \delta_1 rs_{t-1} + (1-\delta_1)[re_{t-1} + \pi_t + \delta_2(\pi_{t+1} - \overline{\pi}) + \delta_3 y_t] + \varepsilon_t^{rs} \tag{16}$$

where, rs_t is nominal interest rate, re_t is real equilibrium interest rate, and $\overline{\pi}$ is inflation target.

Observable variables: Real GDP, inflation, real effective exchange rate, nominal interest rates, real house prices, government balance, and foreign interest rates.

Unobservable variables: Potential output, output gap, real equilibrium interest rate, real interest rate gap, real equilibrium exchange rate, real exchanger rate gap, real equilibrium house price, real house price gap.

Unit root variables: Real GDP, real equilibrium house prices, real house prices, real exchange rate, and real equilibrium exchange rate

Sample: EMU7 (Austria, France, Germany, Italy, Netherlands, Portugal, and Spain).

Sample period: 1970–2006.

Frequency: Quarterly, annual.