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Physical Capital Adjustment within Spain: Long-Run and Short-Run Analysis

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Physical Capital Adjustment within Spain: Long-Run and Short-Run Analysis

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Abstract

This paper considers the adjustment of physical capital within a country in the long run and in the short run. It uses a unique data set on income, labor, human capital, and private and public physical capital in the Spanish regions over the past two decades. In the long run, the movement of physical capital is consistent with its estimated relative rates of return. In the short run, an adverse shock to a region results in a sharp drop in employment and a gradual decline of physical capital; the system returns to its initial capital/labor ratio after four years. The sharp drop in employment is consistent with the view that wages are rigid. The analysis of adjustment in the short run relies on a vector autoregression methodology in which shocks are identified as the interaction between oil prices and the share of manufacturing in a region's employment.

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I. INTRODUCTION

Large differences in unemployment rates have persisted for a number of decades among the Spanish regions, and have been associated with macroeconomic costs—a higher NAIRU and lower potential output—and social distress. Differences in per capita incomes also remain large, having declined only gradually over the past few decades. In highly flexible markets, differences in both unemployment rates and per capita incomes might have been reduced rapidly through adjustment in both the labor market and the capital market. Previous studies have shown that large and persistent unemployment differences among the Spanish regions may be attributed in part to labor market rigidities, including a relatively centralized wage bargaining system (Mauro, Prasad, and Spilimbergo, 1999).[2] The question of why capital does not move to correct unemployment imbalances, however, has not been addressed in previous work; the role of capital movement in the convergence of per capita income incomes also deserves further consideration. This paper seeks to fill these gaps, and to complement previous work on labor market adjustment, by focusing on capital market adjustment.

More generally, capital market adjustment remains a relatively unexplored area in economics—certainly by comparison with labor market adjustment. Most of the existing work on capital market adjustment has addressed the issue of why capital does not move to developing countries, where it is relatively scarce. Previous research on this issue, exemplified by a seminal article by Lucas (1990), has typically focused on long-run developments in relative per capita incomes and relative capital abundance. The present paper applies a similar approach to the Spanish regions, drawing on exceptionally detailed data sets on income, labor, private capital, public capital, and human capital collected by the *Instituto Valenciano de Investigaciones Económicas* and *Fundación Banco Bilbao Vizcaya*.[3] Using a vector autoregression methodology, it also estimates the short-run response of physical capital to regional shocks, which has not been analyzed in previous work on Spain or other countries.

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[2] Differences across regions in real wages and unit labor costs are too small and unrelated to unemployment differences to reinforce incentives for workers to migrate out of, and for firms to migrate toward, high unemployment regions.

[3] The data on private capital, public capital, gross domestic product, and employment are drawn from *Fundación Banco Bilbao Vizcaya*, and are available via the Internet at http://bancoreg.fbbv.es. The data on human capital are drawn from *Instituto Valenciano de Investigaciones Económicas*, and are available via the Internet at http://www.ivie.es.

II. Long-Run Analysis

This section analyzes long-run developments in private capital stocks for the 17 Spanish regions. It shows that developments in the regions' private capital stocks have responded to differences in the rate of return on capital, resulting in gradual convergence of the regions' capital/labor ratios. At the same time, the rate of return on capital does not seem to be higher in high-unemployment regions and, consistent with this, no tendency has been observed for capital to move toward high-unemployment regions. Unemployment differences are thus not being corrected through this mechanism.

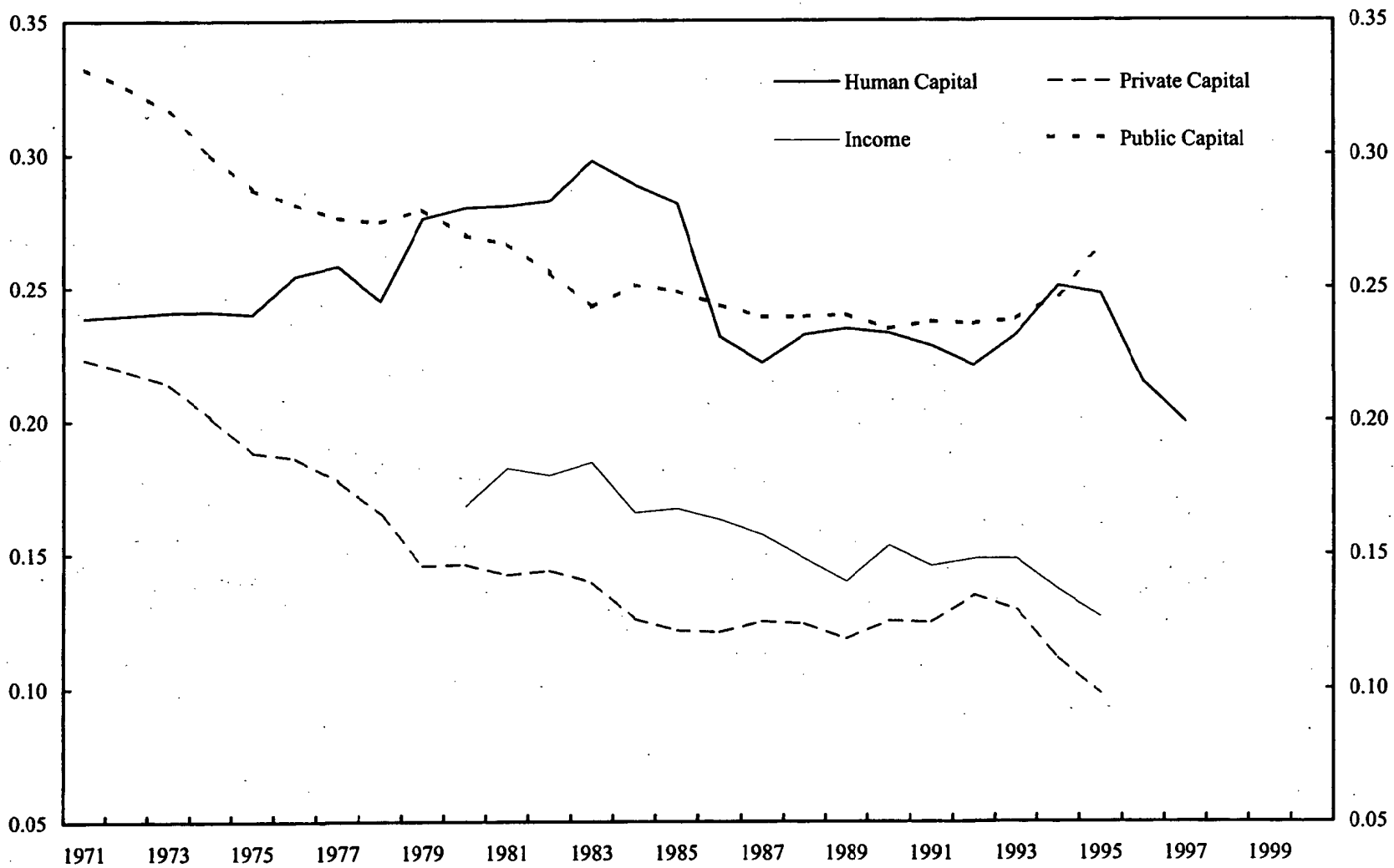
A. Capital Movement and Per Capita Incomes Across Regions

While previous studies (including Dolado et al., 1994, and García-Greciano et al., 1999) have shown that GDP per capita and GDP per employee have converged across the Spanish regions during the past few decades, these studies have not focused on the extent to which this is accounted for by convergence in the various factors of production. Using a detailed data set on private capital, public capital, and educational attainment, this paper shows that private capital per employee has converged, albeit gradually, since 1970 (despite some divergence in 1986–92, a period characterized by large external shocks). In this respect, private capital has evolved in accordance with the *law of diminishing returns*, under which a factor will flow toward the regions where it is relatively scarce, that is, where its marginal product is higher. By contrast, human capital has not shown much tendency to converge, and public capital converged slowly and only until 1990. This is confirmed by developments in the coefficient of variation (standard deviation divided by the mean) across the 17 Spanish regions for GDP and the endowments of public capital and private capital, all as a ratio to employment, and human capital (defined, for simplicity, as the share of employment with a secondary or higher degree), in 1967–95 (Figure 1). The capital/labor ratio has therefore displayed convergence in dispersion (or σ-convergence).

Moreover, the capital/labor ratio has tended to rise more rapidly in regions that started off with a lower-than-average ratio, i.e., it has also displayed β-convergence. In a panel regression of the change in the regional private capital/labor ratio on the lag of the regional private capital/labor ratio, human capital, public capital, yearly dummies to control for nationwide developments, and regional dummies, the estimated speed of convergence is about 4½ percent a year (Table 1).

In this sense, therefore, private capital has moved, albeit gradually and slowly, from capital-rich regions to capital-poor regions.

Figure 1. Spain: Coefficients of Variation, 1971-1998



Sources: Instituto Valenciano de Investigaciones Economicas and staff calculations.

Table 1. Determinants of Investment in the Spanish Regions
Dependent Variable $\Delta[\ln(K/L)]_t$

	Coefficient	Standard Error	t
$\ln(K/L)_{t-1}$	-0.046	0.011	-4.10
$\ln(P/L)_{t-1}$	-0.018	0.009	-1.97
$\ln(H/L)_{t-1}$	-0.000	0.013	-0.01

Note: There are 510 observations. The list of right-hand-side variables also includes 17 regional dummies and 29 yearly dummies, whose coefficients are not reported for the sake of brevity. K/L is the private capital to labor ratio. P/L is the public capital to labor ratio. H/L is the human capital to labor ratio.

B. Capital Movement and Regional Unemployment

By contrast, private capital has not moved from low-unemployment regions to high-unemployment regions. This finding might reflect two possibilities: first, that the return on capital is unrelated to regional unemployment rates; second, that the magnitude of regional shocks and the relatively slow pace of capital adjustment are such that the regions are almost always in disequilibrium. Both possibilities seem plausible, and they might well coexist: they are considered in the next sections.

Private capital might have been expected to flow toward regions with relatively high unemployment, whether because of the availability of large numbers of unemployed workers, or because of lower wages possibly associated with high unemployment, assuming that the relative availability of other factors, such as human capital or public capital, did not offset this tendency.

To estimate the return to private capital in the various regions, and to assess the extent to which regional differences in the return to private capital are accounted for by differences in public capital and human capital, it is assumed that a region's production function takes a Cobb-Douglas form as follows:

$$Y_i = A_i K_i^{\alpha} L_i^{\beta} P_i^{\gamma} H_i^{\delta}$$

Where Y is output, K is private capital, L is labor (the number of workers, regardless of education), P is public capital, H is human capital,[4] A is total factor productivity (a residual),

[4] The human capital index is employment with secondary or higher education as a share of total employment.

and the subscript i denotes region i. The return to private capital is the marginal product of capital:

$$R_i = Y_i / K_i = A_i \alpha K_i^{\alpha-1} L_i^{\beta} P_i^{\gamma} H_i^{\delta}$$

Taking logarithms, rearranging, and taking differences with respect to the national average (the latter denoted by subscript E), the difference in region i's return to private capital with respect to the national average consists of the following components:

$$ln(R_i) - ln(R_E) = (\alpha-1)\,[ln(K_i/L_i) - ln(K_E/L_E)] + \gamma[ln(P_i/L_i) - ln(P_E/L_E)] +$$

$$+ \delta[ln(H_i/L_i) - ln(H_E/L_E)] + [ln(A_i) - ln(A_E)] - (1-\alpha-\beta-\gamma-\delta)\,[ln(L_i) - [ln(L_E)]$$

Figure 2 shows the various components of the difference between the marginal return to private capital in the 17 Spanish regions and the national average in 1990, assuming that $\alpha=\beta=\gamma=0.3$ and $\delta=0.1$.[5] For example, the relatively low marginal return on private capital in Galicia is largely accounted for by Galicia's relatively high stock of private capital per worker.

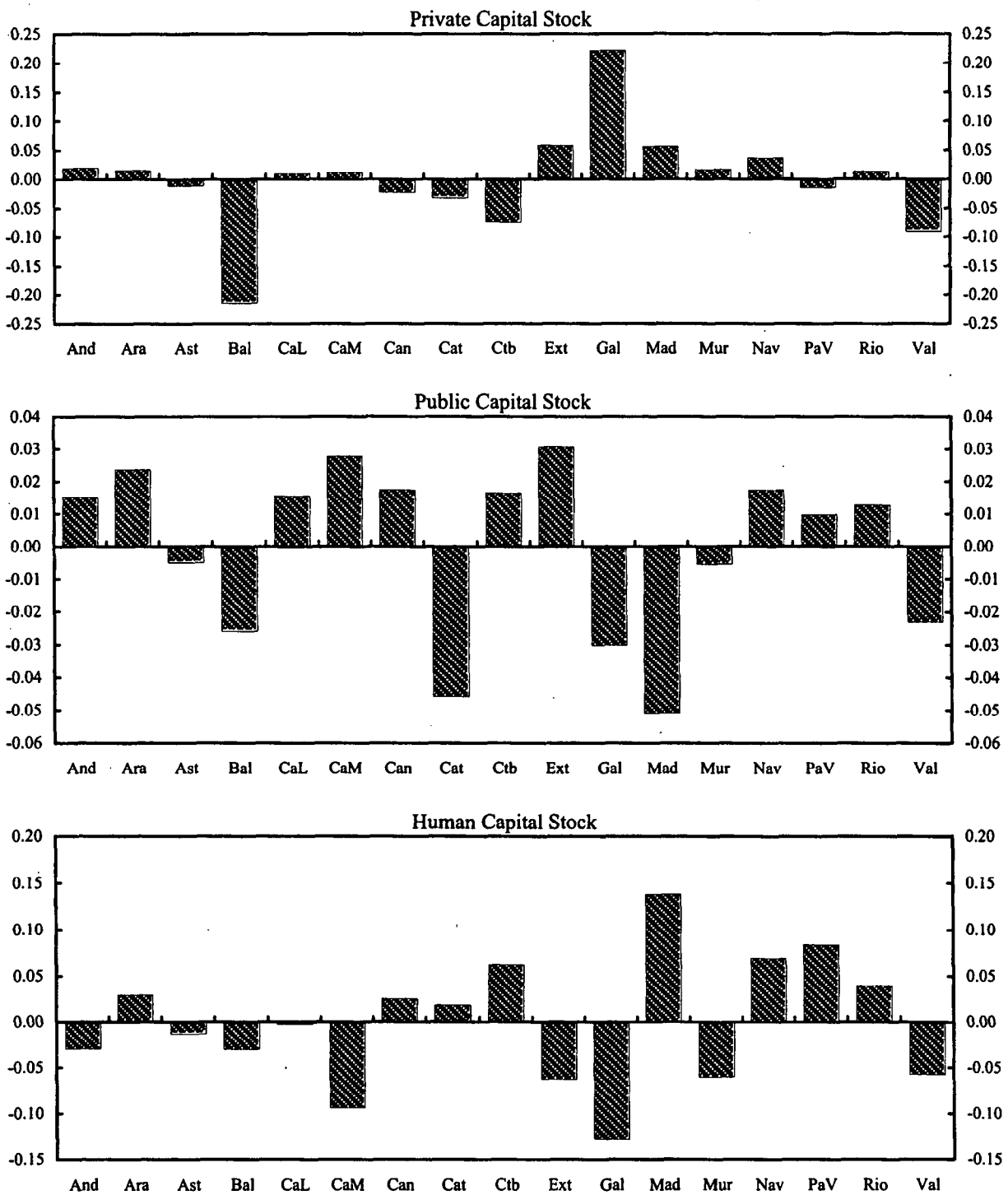
The key message from Figure 2 is that the extent to which differences in public capital and human capital account for differences in returns on private capital among the Spanish regions is rather limited; differences in private capital stocks per worker play a much greater role in this respect.

Nevertheless, differences in the estimated return to private capital across the regions are large, and they might provide incentives for private capital to move toward regions with higher relative returns. However, the estimated return to private capital is not significantly associated with regional unemployment. Figure 3 shows the correlation between the unemployment rate and the estimated total return on capital (constructed from the formula above assuming that A_i is the same for all regions) in 1990. The main message is that there is no apparent correlation between the rates of return and local unemployment rates. Therefore, despite the persistence of large regional differences in unemployment rates, no significant evidence of failures in the capital market is found using this approach.

Regression analysis on a panel of the Spanish regions in 1966–95 does not yield significant evidence of any positive link between unemployment and investment, either. Adding the unemployment rate to the set of explanatory variables used in the regressions whose results are reported in Table 1, the coefficient on the unemployment rate does not turn out to be significant.

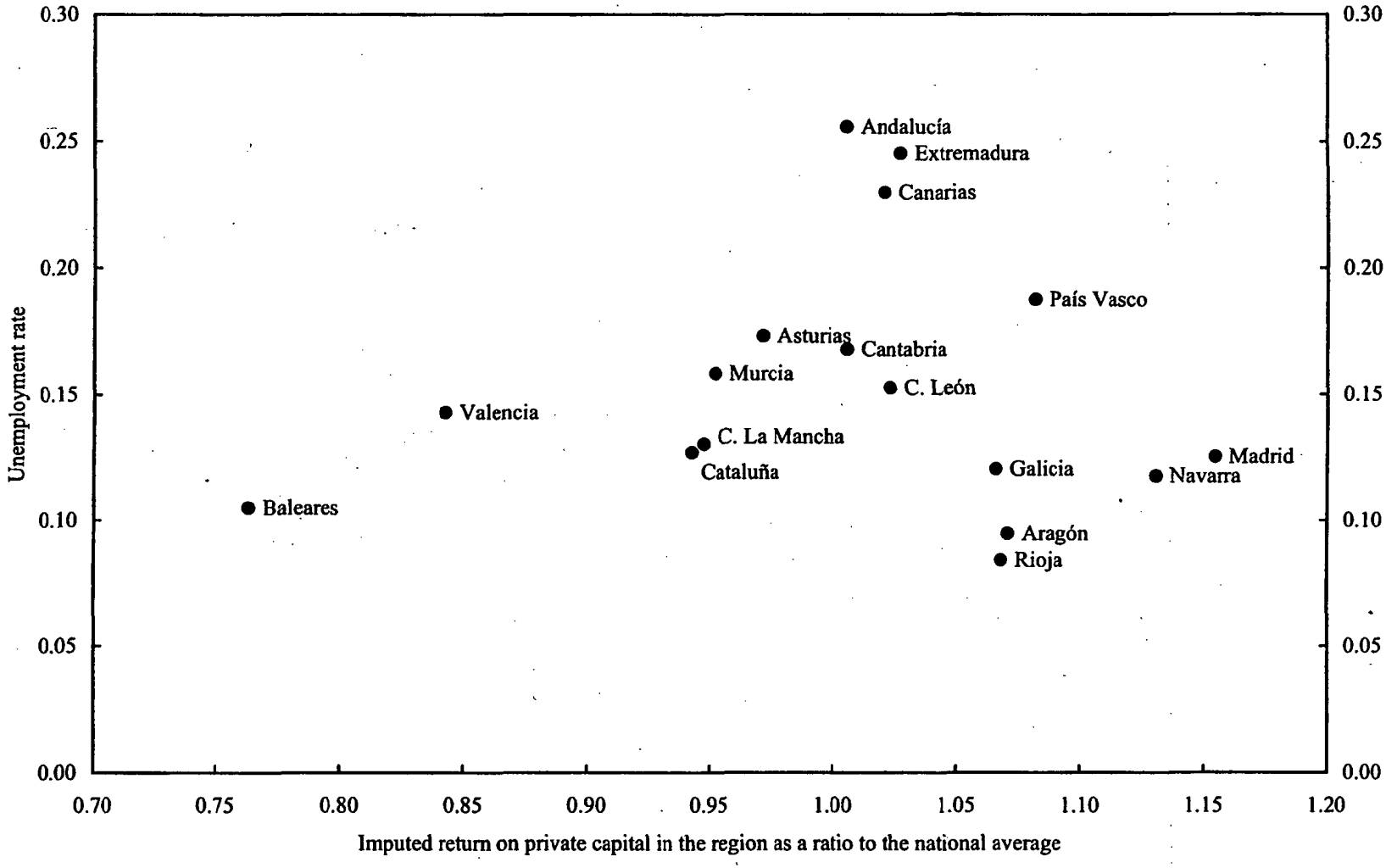
[5] The results do not change much using alternative parameter values within a plausible range.

Figure 2. Spain: Decomposition of Rate of Return on Private Capital, 1990
(Contribution of each factor of production to the difference between the rate of return in each region and the national average)



Sources: Instituto Valenciano de Investigaciones Economicas and staff calculations.
Note: And = Andalucia; Ara = Aragon; Ast = Asturias; Bal = Baleares; CaL = Castilla-Leon; CaM = Castilla La Mancha; Can = Canarias; Cat = Cataluna; Ctb = Cantabria; Ext = Extremadura; Gal = Galicia; Mad = Madrid; Mur = Murcia; Nav = Navarra; PaV = Pais Vasco; Rio = Rioja; Val = Valencia.

Figure 3. Spain: Scatter Plot of Unemployment and Return on Private Capital, 1990



Sources: Instituto Valenciano de Investigaciones Economicas and staff calculations.

These results suggest that even though private capital gradually responds to differences in returns across regions, returns are not higher in higher-unemployment regions; accordingly, there is no tendency for capital to move toward regions with relatively high unemployment.

III. Short-Run Analysis

This section analyzes the response of a region's capital, labor, and output to a regional shock. Specifically, it asks the following questions: when a region is hit by a shock that results in lower output growth, to what extent does the adjustment take place through a slowdown in labor input, capital input, and total factor productivity? How rapidly do capital and labor adjust? Does the immediate impact of the shock differ from its long-run effect?

In order to answer these questions, a vector autoregression system is estimated for a panel consisting of the 17 Spanish region over 1983–95, with equations for (i) capital accumulation, (ii) employment growth, and (iii) GDP growth. Before moving to the estimation, two preliminary issues need to be addressed. First, how are national shocks reflected in regional variables, and what is the most appropriate way to control for national shocks? Second, as changes in output growth and input growth are jointly determined, how can exogenous shocks to the regions be identified?

A. Regional Response to National Shocks

Regional economies are subject to both national shocks, such as changes in monetary policy or oil prices, and regional shocks, such as a bad weather in the region. Moreover, the various regions may respond differently to national shocks: for example, the effects of an oil price shock may be expected to be smaller in agricultural regions than in industrial regions. In order to assess whether the response of employment, private capital, and output to national shocks is similar across regions, the following regression is estimated for each region:

$$\Delta X_{it} = \alpha_i + \beta_i \Delta X_t + \epsilon_{it},$$

where X can be employment, private capital, or output, ΔX_{it} is the regional growth rate, and ΔX_t is the national growth rate. There is considerable variation in the estimated β_i coefficients: an increase in national employment growth rate by 1 percentage point is associated with extra regional employment growth ranging from 1.2 percentage points in Catalonia to 0.5 percentage point in Cantabria or Galicia. Similar variation is evident in the response of regional investment or output to national developments.

The appropriate way to control for national shocks in the VAR system estimation is therefore by using yearly dummies, because this allows the regional responses to national shocks to differ across regions.[6] By contrast, the much-used Blanchard-Katz (1992) method, which

[6] Given the large sample, using yearly dummies is not very costly in terms of reduced degrees of freedom.

consists of using regional differences with respect to the national average when estimating the VAR system, would not be appropriate in this case because it assumes that the responses of regional employment to the national business cycles are the same for all regions.

Besides providing information on the appropriate way to control for national business cycles, the previous analysis gives information on the relative importance of regional and national shocks for employment, the capital stock, and income. Innovations in regional employment can be explained by national developments in employment to a lesser extent than developments in regional capital stocks can be explained by national developments in the capital stock; national developments play an even smaller role in the case of income. The average R^2 is 0.55 in the employment regressions, 0.73 in the private capital growth regressions, and 0.40 in the income growth regressions.[7]

B. Identification and Shocks

To identify exogenous shocks to the regions, this paper considers an external shock—a change in the price of oil—and makes use of the fact that its impact on the various regions will differ in a predictable manner.[8] The exogenous shock is defined as:

$$Shock_{it} = (price\ of\ oil\ in\ real\ terms)_t * share\ of\ workers\ in\ manufacturing_i$$

When the real price of oil increases,[9] all regions will be adversely affected, but some regions—presumably those with a greater share of manufacturing in regional employment[10]—will be affected more strongly than others will.[11] This section considers how

[7] By comparison, the R^2 on analogous regressions for employment growth is 0.66 in the 50 U.S. states (Blanchard and Katz, 1992) and 0.20 in the European regions (Decressin and Fatás, 1995). A factor that may contribute to a lower R^2 in Spain than in the United States may be that agriculture—a sector that is especially prone to regional shocks—plays a larger role in Spain than in the United States.

[8] Identification is attained only thanks to the fact that these external, nationwide shocks interact with region-specific variables so as to affect the various regions differently but in a predictable manner. Neither nationwide shocks nor region-specific variables would be sufficient to give identification in the absence of these interactions.

[9] The price of oil and the terms of trade index are drawn from the IMF's *International Financial Statistics.* A geometric average of the U.S. and German deflators is used to deflate the price of oil.

[10] The data used to compute the shares of manufacturing employment in total employment are drawn from the *Instituto Nacional de Estadística.*

[11] This strategy to identify exogenous shocks is similar to that adopted by Davis et al. (1997).

these shocks affect regional capital, labor, and output, controlling for developments in the Spanish economy as a whole. In other words, the impulse responses trace the extent to which capital, labor, and output grow more slowly than would be expected on the basis of developments in these variables at the national level.

C. VAR Estimation

The following system is estimated:

$$\Delta Y_{it} = \alpha_{i1} + \beta_1 (L)\, \Delta Y_{it-1} + \gamma_1 (L)\, \Delta L_{it-1} + \delta_1 (L)\, \Delta K_{it-1} + \textit{regional dummies} + \textit{yearly dummies} + \mu_1\, shock_{it-1} + \varepsilon_{iyt}$$

$$\Delta L_{it} = \alpha_{i2} + \beta_2 (L)\, \Delta Y_{it-1} + \gamma_2 (L)\, \Delta L_{it-1} + \delta_2 (L)\, \Delta K_{it-1} + \textit{regional dummies} + \textit{yearly dummies} + \mu_2\, shock_{it-1} + \varepsilon_{ilt}$$

$$\Delta K_{it} = \alpha_{i3} + \beta_3 (L)\, \Delta Y_{it-1} + \gamma_3 (L)\, \Delta L_{it-1} + \delta_3 (L)\, \Delta K_{it-1} + \textit{regional dummies} + \textit{yearly dummies} + \mu_3\, shock_{it-1} + \varepsilon_{ikt}$$

Where Y_{it}, L_{it}, K_{it} are regional income, employment, and capital. Two lags of each variable are included to allow for feedback effects. Annual dummies are included to control for nationwide developments, as explained above. Region-specific trends are included, in light of the evidence on long-run convergence presented above.[12] The sample includes the 17 Spanish provinces and covers the period 1980-1995, yielding 221 observations (allowing for lags).

The results are robust when the same system is estimated using a different shock, defined as a region's openness in 1998 times Spain's terms of trade index. The results are also similar when the system is estimated controlling for human capital and public capital; the baseline specification reported above is more parsimonious in terms of degrees of freedom.

Impulse response functions (Figure 4) trace the response of output, capital, and labor to a one standard deviation shock, where the "shock" variable used in this paper, as mentioned above,

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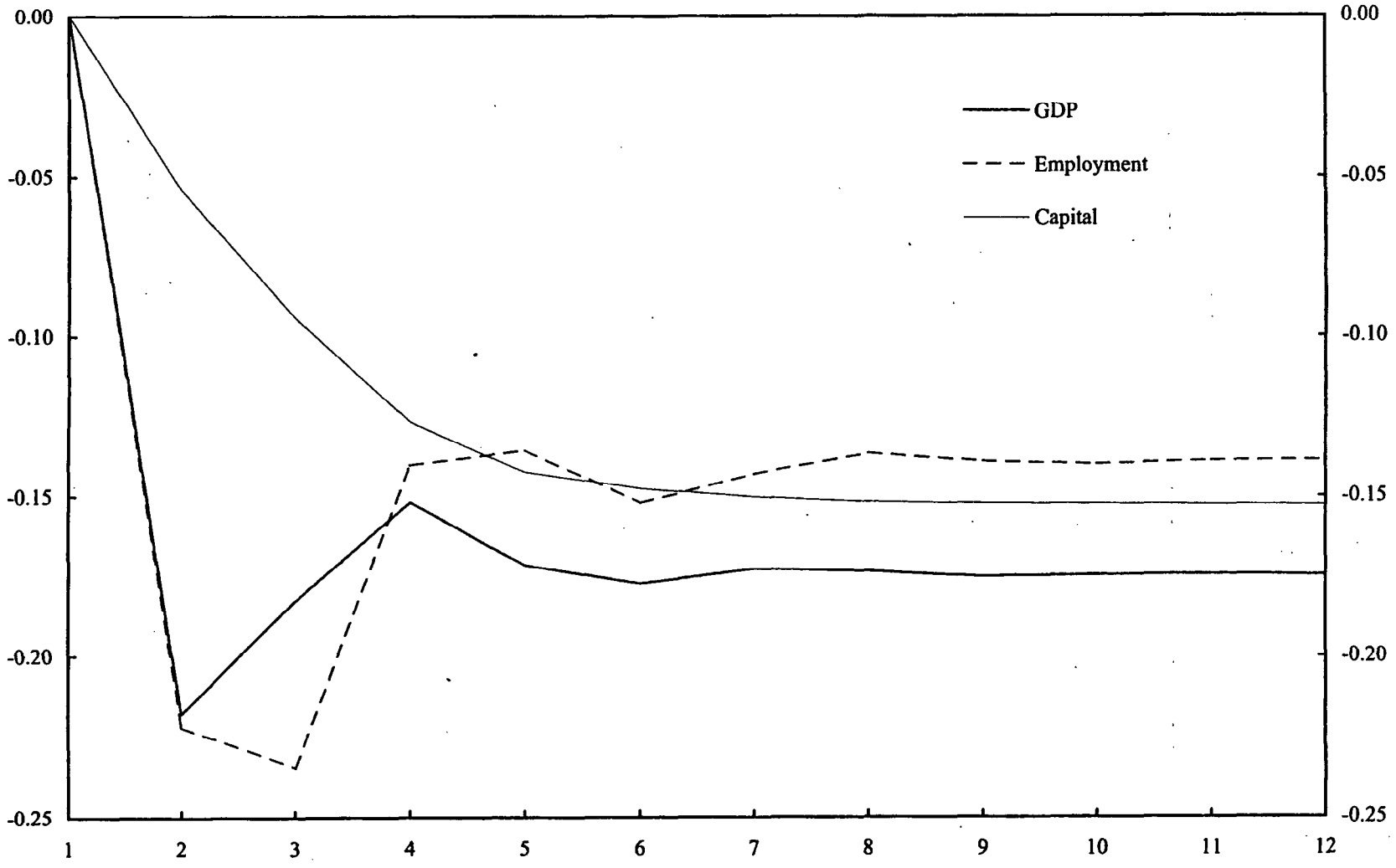
[12] In their seminal paper that first used this type of approach to analyze regional labor market developments, Blanchard and Katz (1992) considered all variables as differences with respect to the national average. By using regional variables while controlling for year-specific dummies to capture nationwide developments, the approach used in the present paper constitutes a simple generalization of the Blanchard and Katz (1992) approach. Straightforward restrictions on the parameters would yield the Blanchard and Katz (1992) approach as a special case, but the restrictions would be rejected by formal specification tests.

Figure 4. Spain: Impulse Responses to a Shock 1/
(Deviations from baseline in percentage points)



Sources: Instituto Valenciano de Investigaciones Economicas and staff calculations.

1/ A shock is defined as a one standard deviation increase in the product of the real price of oil and the ratio of manufacturing employment to total regional employment.

is the real price of oil multiplied by manufacturing employment as a share of total regional employment.[13] The standard deviation of the real price of oil was 13 percent during the sample period considered, and the cross-regional average share of manufacturing employment to total employment was 22 percent. For such a "typical" region, the magnitude of the shock simulated in Figure 4 is the same as that of a one standard deviation shock to the price of oil.[14] The responses of output, capital, and labor to a shock are estimated fairly precisely, as seen from the relatively narrow one standard deviation confidence intervals (Figure 5). The estimated impact on output is a 0.22 percentage point drop taking place entirely in the first year after the shock; output recovers somewhat in the following years, stabilizing at 0.17 percentage point below its preshock level in the long run. The most interesting result is the difference in the dynamic adjustment of capital and labor. The impact on employment is initially relatively strong (-0.23 percentage point in the first year), but employment recovers in the following years to 0.16 percentage point below its preshock level in the long run.[15] By contrast, the impact on capital is gradual: it amounts only to -0.06 percentage point in the first year but becomes stronger over time; it is fully felt after four years, when it stabilizes at about 0.15 percentage point below its preshock level. After four years and in the long run, the proportional decline in capital and labor is the same, that is, the capital/labor ratio is back to its preshock level.

The impulse response functions suggest that the immediate brunt of adjustment falls upon labor, rather than capital, with the capital/labor ratio returning to its preshock level only gradually. This different speed of adjustment is more likely to reflect technical difficulties in altering the capital stock rather than rigidities in the market for physical capital. This

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[13] The impulse responses are calculated under the hypothesis that the current innovations in GDP affect employment and investment but not vice versa. The fact that the elements on the diagonal of the variance-covariance below are much bigger than the off-diagonal elements confirm that alternative orderings of the variables in the system would produce similar results.

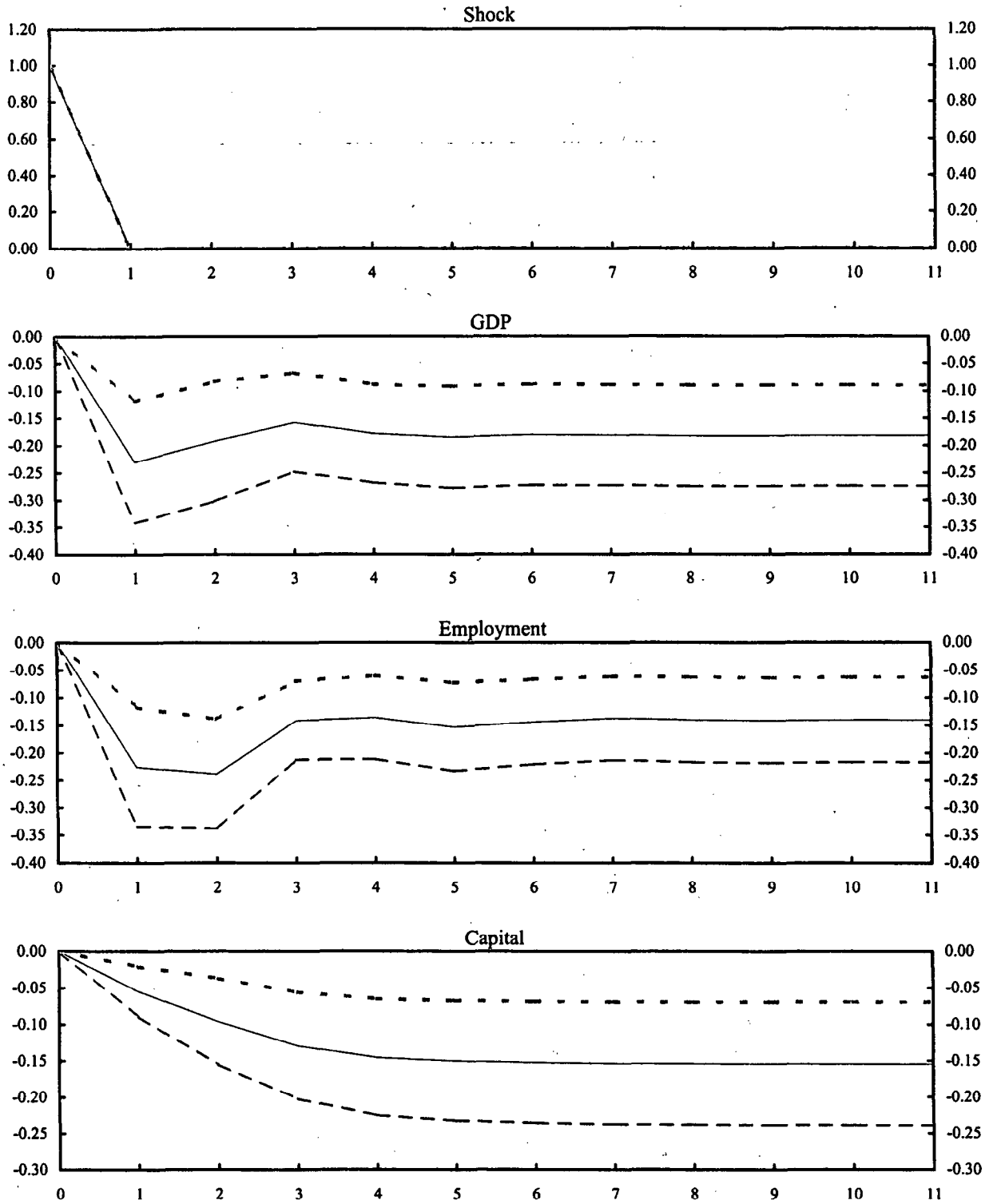
Variance-covariance matrix of the VAR equations:

4.3792e-004		
1.1842e-005	3.6276e-004	
1.1775e-006	8.8215e-006	3.6228e-005

[14] The response to a given change in the oil price displays a similar pattern but is wider (or narrower) depending on whether a region's share of manufacturing employment in total regional employment is higher than average (e.g., Catalonia, 36 percent) or lower than average (e.g. Extremadura, 10 percent).

[15] Total factor productivity also drops sharply in the first year after the shock. This is consistent with the result that changes in a country's economic growth over relatively short time intervals are primarily accounted for by changes in total factor productivity growth (Easterly et al., 1993).

Figure 5. Spain: Impulse Responses and Confidence Intervals 1/



Sources: Instituto Valenciano de Investigaciones Economicas and staff calculations.
1/ One standard deviation bands.

interpretation is consistent with the view that private physical capital is highly firm-specific and can be moved only at a significant cost (Ramey and Shapiro, 2000). Nevertheless, a more firm interpretation of this result cannot be provided in the absence of comparable studies for other countries.

The large drop in employment in the immediate aftermath of the shock raises the question of why adjustment in the labor market takes place to such a large extent through employment rather than wages. One possible interpretation of this result is that it constitutes further evidence of wage rigidities in the labor market in the face of shocks.

IV. Concluding Remarks

This paper has analyzed developments in private physical capital in the Spanish regions. Long-run movements in private physical capital across the Spanish regions seem to have taken place in accordance with relative returns. Controlling for human capital and physical capital, private investment has been higher in regions with a relatively low stock of private capital, and this has been mirrored in convergence of private capital per worker ratios. However, returns to private physical capital have not been significantly higher in high-unemployment regions; accordingly, developments in private physical capital have not helped reduce differences in unemployment rates among regions.

Differences in the stock of private capital per worker seem to have been the main factor accounting for differences in returns on private capital among the Spanish regions, with differences in public capital and human capital accounting for much less. It therefore seems unlikely that policies aimed at changing relative human capital and public capital allocations could significantly alter any of the patterns described above.

The paper has also analyzed the short-run response of capital and labor to shocks. When an adverse shocks hits a region, capital adjusts, but slowly; by contrast, employment drops sharply in the immediate aftermath of the shock, and subsequently rises somewhat. After about four years, the capital/labor ratio returns to its preshock level. A possible interpretation of these findings is that wages are rigid, implying that the brunt of the adjustment to regional shocks must be borne by employment rather than wages.

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