Firm Level Investment and R&D in France and the United States: A Comparison

Benoît Mulkay,[1] **Bronwyn H. Hall**[2] **and Jacques Mairesse**[3]

[1]Université des Antilles et de la Guyane, Campus de Schoelcher, B.P. 7209, 97275 Schoelcher Cédex, Martinique (F.W.I.)
[2]Dept. of Economics, UC Berkeley, Berkeley, California 94708, USA; Nuffield College, Oxford University; and NBER
[3]INSEE-CREST, 15 Boulevard Gabriel Péri, 92245 MALAKOFF Cédex, France; EHESS (Paris); and NBER

Abstract. This paper is a contribution to the small but growing literature that compares the investment and R&D behavior of manufacturing firms in large developed countries that have varying financial and capital market institutions. Specifically, we look at two similar samples of French and United States firms during the period 1982-1993. We estimate a dynamic specification of a simple error-corrected investment model for both ordinary investment and for R&D investment, a model that incorporates both output (sales or turnover) and cash flow as predictors for investment. Our focus is on two comparisons: France versus the United States and physical investment versus R&D investment. In general, we do not find any significant differences between the two countries in the long run effects of demand (output) on investment. However, we do find that cash flow or profits appear to have a much larger impact on both R&D and investment in the U.S. Except for the well-known difference in the serial correlation of the two types of capital spending, we reject any significant differences between investment and R&D behavior for each country; the major differences are between countries.

Keywords. Investment, R&D, financing constraint, liquidity constraint, cash flow sensitivity, international comparison

Acknowledgement. We gratefully acknowledge the helpful comments of our discussants, Julie Ann Elston and Stacey Tevlin, and those of the other participants in the Deutsche Bundesbank Conference on "Investing Today for the World of Tomorrow," held in Frankfurt, April 28-29, 2000. Benoît Mulkay thanks the CNRS for financial support under the program "Les enjeux économiques de l'innovation".

1 Introduction

Recent theoretical and empirical literature on firm-level investment has focused on the role of financial factors and liquidity on the investment decision, partly in an attempt to understand why these factors appear to have as much influence as they do on investment (see Schiantarelli [1996] and Hubbard [1998] for two recent surveys of this literature). An open and somewhat contentious question remains whether these financial factors are proxying for demand shocks or whether their presence in the investment equation indicates that firms are subject to liquidity constraints or an inability to finance all their desired investments.[1]

Some researchers have argued that R&D investment might be expected to be even more sensitive to financial factors than physical investment in equipment and structure (or investment for short), because of its relative risk and lack of easily mortgaged assets, although evidence that this is the case is sparse (Hall [1992]; Himmelberg and Petersen [1994]). The goal of this latter literature is to understand features of financial markets that might inhibit or encourage innovation in established firms.[2] Recently some researchers have begun to use a comparative approach in order to better understand the investment relation; comparisons are made across countries and/or types of investment. Work of this kind includes Hall [1992], who investigates the role of financing constraints on R&D and investment for U.S. firms; Harhoff [1997], who does the same for German firms; and Bond, Harhoff and Van Reenen [1998], who extend Harhoff's analysis to U.K. companies.[3]

The approach taken in the present paper is closest to that in Bond, Harhoff, and Van Reenen [1998], but uses data for French and United States R&D-performing and non-R&D-performing firms. We ask how R&D and investment behaviors at the firm level differ from each other and how they differ across these two countries. One question of interest is thus whether firms affected by a decrease of available funds will reduce their R&D spending more than their investment, or whether they will reduce both types of investment more in one country than another.

We build our analysis on a previous paper (Mairesse, Hall, and Mulkay [1999]) that focused on a set of comparisons between models (accelerator-profit specification of the traditional type versus an error correction specification), between periods (the seventies versus the eighties), between countries (France and the U.S.) and between methods of estimation (the conventional

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[1] Kaplan and Zingales [1997; 2000]; Fazzari,Hubbard and Petersen [2000].

[2] A separate literature focuses on the issues surrounding the financing of start-ups and entrepreneurial firms, including the use of venture capital. See, for example, Berger and Udell [1998].

[3] See also Bond, Elston, Mairesse and Mulkay [1997], who compare the investment behavior of French, Belgian, German and British firms and Hall, Mairesse,Branstetter and Crépon [1999] who conduct a causal analysis for investment, R&D, sales and cash flow across French, Japanese, and U.S. firms.

total, between and within-firm estimates versus the newer GMM methods for panel data). By constructing datasets that are as comparable as possible in the two countries and using a set of comparisons that differ in only one dimension, we hope to understand better where financial factors might impinge on investment and R&D. For example, our finding that the cash flow effects in the R&D and investment equations do not differ within country but do differ across the two countries suggests that the most important reason that financial factors affect investment is not the type of investment (whether or not it can be used as debt security; the degree of asymmetric information between the firms and their financiers) but the financial market environment in which the investment is being undertaken.

We consider a simple neo-classical model for the determination of the optimal (or long-run, or equilibrium) level of both physical investment capital, or "fixed" capital, and R&D capital or "knowledge" capital. We do not explicitly assume a given formulation of costs of adjustment, but we allow for a two year adjustment process whose form is determined empirically. We show how to rewrite this model as an error correction specification that allows us to separate long and short-run effects of sales and cash flow on investment and R&D. Our model includes a firm-specific effect which takes care of permanent differences across firms in net and gross investment rates. In Appendix A, we indicate how our model is directly related to the traditional accelerator-profit specification that has been very much used in earlier research and that we also used in Mairesse, Hall and Mulkay [1999] when reproducing some of this earlier work.

The model is estimated on two panel data samples of about 500 large manufacturing firms for the period 1982-1993 in France and the United States. In Appendix B, we describe in some details the construction of the samples and the measurement of the main variables in the analysis. We have performed both within-firm and GMM estimators, but with a preference for the former. Recently, evidence has been accumulating that the use of GMM estimation where only weak instruments are available is problematic, in the sense that it is very imprecise (and possibly biased when the sample size is not very large, much larger than that of our samples).[4] This feature of GMM is especially worrisome for comparative purposes because it implies that we will accept similarity of behavior between countries, between sub-samples or between investment and R&D behavior when it is not present. This is why we prefer to use the usual least-squares within-firm estimates here. They are similar to the point estimates of GMM but with smaller standard errors (which implies that using instruments does not have much impact, and that in particular the

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[4] See for example: Arellano and Bond [1991], Arellano and Bover [1995], Ahn and Schmidt [1995], Blundell and Bond [1998]; or also Crepon and Mairesse [1995], Mairesse and Hall [1996], Griliches and Mairesse [1998] and Mairesse, Hall and Mulkay [1999].

bias introduced by the within transformation is rather small).[5] In Appendix C, we present the ("first differenced" and "system") GMM estimates for our model briefly and compare them with the within-firm estimates.

In addition to estimates of the investment relation based on data from a single country for each type of investment, we consider estimates pooled across the two countries and the two type of investments, in order to test explicitly for cross-countrry differences and investment type differences in investment determinants. In general, we do not find any significant differences across type of investments, nor between France and the U.S. in the long run effects of demand. However profits or cash flow appear to have a much larger impact on investment in the U.S. than in France (where the impact is essentially zero). A possible interpretation of this finding is that, because the U.S. firms operate in a much thicker and more responsive capital market, cash flow changes, whether due to liquidity or demand shocks, have a more immediate impact on investment behavior in that country.

In the following, we first explain our error correction version of the accelerator-profit model of investment and R&D (section 2), make some remarks on estimation issues (section 3), and show the descriptive characteristics of our samples and variables (section 4). We then present and comment on our main estimation results (section 5), and conclude on our most significant findings (section 6).

2 The Empirical Model of Investment and R&D: Long Run and Short Run Specification

We consider a simple neo-classical model for the determination of the optimal (or long-run, or equilibrium) level of physical or fixed capital and of R&D or knowledge capital. Because we want to compare the investment or R&D behavior of the French or American firms, we prefer to rely on a simple model for both countries rather than focusing on finding the "correct" model of investment and R&D. The investment and the R&D decisions of the firms are treated in an identical manner by specifying a simple long-run relationship between the fixed or knowledge capital stocks, the demand faced by the firm and the user cost of fixed or knowledge capital. We leave the adjustment process to be determined by the data by assuming a flexible dynamic specification for both equations, an autoregressive distributed lags specification.

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[5] As we mention later, this bias comes from the presence of the lagged dependent variable and other predetermined variables in the model and the fact that the firm-level means subtracted from these variables before estimation are computed over the whole period of estimation (in the usual within firm transformation). This bias, however, declines fairly quickly with T, the number of years in the period of estimation, and in our case T is 12. See Nickell [1981] and Chamberlain [1982].

In order to take account of the financial constraints faced by the firm, we add a profit rate (more precisely, a cash flow rate) to the specification. To be consistent with the simple neo-classical long run model, the profit rate should have only short run effects on investment or R&D spending. However, if this variable appears in the long run relation as well, that may be explained by the irreversibility of the installed capital stock in a context where there is uncertainty on future demand. The optimal level of capital stock in this case depends not only on the user cost of capital and the expected demand, but also on the profitability of the firm and the variability of the future demand.[6]

We thus begin with the neoclassical demand for fixed and knowledge capital where the long run capital stock of the firm is proportional to output and the user cost of capital. This model is derived by assuming a profit-maximizing firm with a CES production function in fixed and knowledge capital and in labor (and materials). The model yields the following long run optimal demand for fixed capital (K)and knowledge capital (G), expressed in terms of their logarithms k and g:

$$k^*_{it} = \alpha_t + \beta s_{it} - \sigma c_{it} \tag{1}$$

and

$$g^*_{it} = \alpha'_t + \beta s_{it} - \sigma c'_{it} \tag{2}$$

where the subscripts denote firm i and year t, where β is the (long run) elasticity of sales to capital and the α_t and α'_t are (time varying) technical change parameters, and where s_{it} is the log of output, and c_{it} and $c^{'}_{it}$ are the logs of the user cost of fixed capital and knowledge capital.[7]

The user cost of capital variables $C_{it} = (P^I_t/P_t)(r_t \frac{P^I_{t-1}}{P^I_t} + \delta_i - \frac{\Delta P^I_t}{P^I_t})$ or $C'_{it} = (P^{RD}_t/P_t)(r_t \frac{P^I_{t-1}}{P^I_t} + \delta'_i - \frac{\Delta P^I_t}{P^I_t})$ (where P_t is the output price; P^I_t and P^{RD}_t are the investment and R&D prices; δ_i and $\delta^{'}_i$ are the depreciation rates of fixed and knowledge capital, which can differ across firms), are typically difficult to measure at the firm level, mainly because these prices are not available (or even meaningful) at the firm level, although they are available

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[6] See Malinvaud [1987] and Lambert and Mulkay [1990].

[7] More precisely, if we write the CES production function as

$$f(L_t, K_t) = A_t \left[aL_t^{\frac{\sigma-1}{\sigma}} + bK_t^{\frac{\sigma-1}{\sigma}} + cG_t^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}\nu}$$

where σ and ν are the production function elasticity of substitution and returns to scale parameters, it can be shown that $\beta = (\sigma + (1 - \sigma)/\nu)$. Note that this model embeds both the special case of a Leontieff fixed coefficient production function ($\sigma = 0$), where the capital-output ratio does not depend on cost and the sales elasticity of capital β is $1/\nu$ (as it would be for demand-constrained firms) and the case of a Cobb-Douglas production function ($\sigma = 1$) where the sales elasticity β is one. Note also that if the returns to scale are constant ($\nu = 1$), we would also obtain a unitary sales elasticity β, regardless of the value of σ. See Appendix A in Mairesse, Hall, and Mulkay [1999] for details on the derivation.

at the more aggregated level of the industry or the whole economy. For this reason, and because depreciation rates can be different between firms, we prefer to control for variations in user costs by including firm-specific and time-specific effects in estimation; all of these effects will be contained in the additive terms $\alpha_t - \sigma c_{it}$ or $\alpha'_t - \sigma c'_{it}$, which are therefore specialized to the additive form $\alpha_t + \alpha_i$. Although this assumption rules out firm (or industry) specific variations over time in the user costs of capital (or in the technical change parameters), it will account for most of the variation in user costs.

We then specify the dynamic adjustment mechanism between the desired and the actual capital stock within a broad class of dynamic models: the autoregressive distributed lags model.[8] Based on our earlier work, we have chosen to use two lags in both the autoregressive and the distributed lag portions, that is, an ADL(2,2) model. This yields the following dynamic equation for the fixed capital stock:[9]

$$\begin{aligned} k_{it} = \alpha_i + \alpha_t + \gamma_1 k_{i,t-1} + \gamma_2 k_{i,t-2} \\ +\beta_0 s_{it} + \beta_1 s_{i,t-1} + \beta_2 s_{i,t-2} + \varepsilon_{it}, \end{aligned} \tag{3}$$

As written in Appendix A, differentiating this model with respect to time yields the traditional accelerator specification where the growth rate of capital stock is related to the growth rate of output (sales), and which has been considered for example by Eisner [1978] and Oudiz [1978] in their seminal studies of the firm's investment behavior on panel data.[10] We compared the use of this specification to an error-corrected one in Mairesse, Hall, and Mulkay [1999]. Our conclusion was that the error-corrected accelerator specification is to be preferred because it explicitly separates long and short run behavior, and because it does not remove a priori all the information in levels from the data contrary to the first differenced specification.

To obtain the error-corrected form of equation (3), we subtract $k_{i,t-1}$ from both sides and rewrite it as:

$$\begin{aligned} \Delta k_{it} = {} & \alpha_i + \alpha_t + (\gamma_1 - 1)\Delta k_{i,t-1} + \beta_0 \Delta s_{it} + (\beta_0 + \beta_1)\Delta s_{i,t-1} + \\ & +(\gamma_2 + \gamma_1 - 1)(k_{i,t-2} - s_{i,t-2}) \\ & +(\beta_0 + \beta_1 + \beta_2 + \gamma_1 + \gamma_2 - 1)s_{i,t-2} + \varepsilon_{it} \end{aligned} \tag{4}$$

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[8] See, for example, Hendry, Pagan, and Sargan [1984] or Davidson and MacKinnon [1993].

[9] The specification for knowledge capital is obtained for the R&D investment by replacing (k) by (g). Note that we assume that there is no significant interaction between the adjusment processes of the two types of capital.

[10] In these studies, however, in order to avoid the biases in the usual estimators arising from the presence of the lagged dependent variables in the list of regressors, Eisner and Oudiz approximate the autoregressive specification of the accelerator model by a long series of distributed lags of the explanatory variables.

In this version of the equation, the term involving the level of sales $(s_{i,t-2})$ can be used to test the departure from the hypothesis of a unitary elasticity of capital to sales directly by testing the nullity of its coefficient $(\beta_0+\beta_1+\beta_2+\gamma_1+\gamma_2-1=0)$. In addition, we expect a negative coefficient for the error correction term $(k_{i,t-2}-s_{i,t-2})$ indicating that investment is higher when capital stock is less than its optimal level, and conversely. This is equivalent to the necessary condition for the stationarity of the capital stock in the autoregressive model $(\gamma_1+\gamma_2<1)$.

Investment equations of this type are often augmented with profit rate variables, such as current and lagged cash flow rates, in order to capture the effects associated with the existence of liquidity constraints or with changes in profitability that are not captured by the growth of sales variables. The cash flow is a measure of the internal financing capacity of the firm coming from its current or past profits, as well as an indicator of its capacity to attract external finance from banks or financial markets.

We measure our cash flow rate variables as the ratio of cash-flow CF (i.e., net profits plus depreciation allowances) to the beginning of period capital stock (valued at replacement cost). Because investment in fixed assets is typically not expensed, but instead capitalized and depreciated over time, this measure of cash flow is *gross* of investment expenditures (corresponding to the overall internal current funds available for investment). But contrary to physical investment, R&D investment is expensed, rather than capitalized, in the current accounts of firms in both countries. Thus, as suggested by Hall [1992], we thought at first that it would be appropriate to add R&D investment back into the cash flow measure in order to treat it symmetrically with ordinary investment. However, when we used this correction, we found clear evidence of measurement error and spurious correlation problems, arising from the simultaneity between the adjusted cash flow and R&D investment, which were especially substantial in the French data. Hence in this paper, after various experiments, we chose to use a cash flow measure that is *net* of R&D investment (although gross of ordinary investment). In the reported estimates in this paper, we have also chosen the replacement value of both fixed and knowledge capital stock $(CAP_{i,t-1}=K_{i,t-1}+G_{i,t-1})$ for the denominator of the cash flow-capital ratio. The changes in the estimates when using only K_{t-1} for normalisation are in line of what we expect on the basis of the relative average magnitude of the two types of capital.[11]

Including the profit rate variables Π_{it}, defined as the cash flow-capital stock ratio $CF_{it}/CAP_{i,t-1}$, in the investment and R&D equations, and using the investment and R&D ratios $I_{it}/K_{i,t-1}$ and $RD_{it}/G_{i,t-1}$ as proxies for the net growth rate of capital stock $(I_{it}/K_{i,t-1}=\Delta k_{it}+\delta_i$ and $RD_{it}/G_{i,t-1}=\Delta g_{it}+\delta_i^{'})$, we finally obtain the specification of the error

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[11] See Mairesse, Hall, and Mulkay [1999] for examples of the impact of such normalisation rules.

correction accelerator-profit model used in this paper. For the investment equation, it can be written (after reparametrization) as:

$$\begin{aligned}\frac{I_{it}}{K_{i,t-1}} &= \alpha_i + \alpha_t + \eta_1 \frac{I_{i,t-1}}{K_{i,t-2}} + \xi_0 \Delta s_{it} + \xi_1 \Delta s_{i,t-1} \\ &\quad + \rho(k_{i,t-2} - s_{i,t-2}) + \lambda s_{i,t-2} \\ &\quad + \theta_0 \Pi_{it} + \theta_1 \Pi_{it-1} + \theta_2 \Pi_{it-2} + \varepsilon_{it}\end{aligned} \tag{5}$$

with $\eta_1 = \gamma_1 - 1$, $\xi_0 = \beta_0$, $\xi_1 = \beta_0 + \beta_1$, $\rho = \gamma_1 + \gamma_2 - 1$, $\lambda = \beta_0 + \beta_1 + \beta_2 + \gamma_1 + \gamma_2 - 1$.

The long run properties of this specification depend only on the terms in levels while the short run adjustment process involves all the parameters. The long run elasticity of capital to sales is thus equal to:

$$\mu_{Sales} = 1 - \frac{\lambda}{\rho}$$

while the long run coefficient of cash flow or profits is equal to:

$$\mu_{Profit} = -\frac{\theta_0 + \theta_1 + \theta_2}{\rho}$$

We can test for the presence of sales or profits by considering the joint significance of β_0, β_1 and β_2 or that of θ_0, θ_1 and θ_2. We can also test for the presence of lag two effects (that is, for the length of the adjustment lag) by looking at the joint significance of β_2, γ_2 and θ_2.

We can estimate four equations in total, for investment and R&D in France and the U.S. respectively. However, in the comparison of investment or R&D behavior across countries, we proceed more rigorously by stacking the investment and R&D equations for the two countries and by testing the equality of parameter estimates using the standard t-tests or Wald tests for the joint significance of the differences.[12] Similarly, in the comparison of the investment and R&D equations, we stack the two types of equations together. In these comparisons, we test for equality of all the parameters, as well as for equality of the long run effects of sales or profit only. For the latter tests we use the following version of equation (5), in which the long-run parameters μ_{Sales} and μ_{Profit} appear explicitly:

$$\begin{aligned}\frac{I_{it}}{K_{i,t-1}} &= \alpha_i + \alpha_t + \eta_1 \frac{I_{i,t-1}}{K_{i,t-2}} + \xi_0 \Delta s_{it} + \xi_1 \Delta s_{i,t-1} \\ &\quad + \rho(k_{i,t-2} - s_{i,t-2}) + \rho(1 - \mu_{Sales}) s_{i,t-2} \\ &\quad + \theta_0 \Pi_{it} + \theta_1 \Pi_{i,t-1} \\ &\quad - (\rho \mu_{Profit} + \theta_0 + \theta_1) \Pi_{i,t-2} + \varepsilon_{it}\end{aligned} \tag{6}$$

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[12] We use these types of tests throughout rather than conventional F-tests based on the sum of squared residuals, since they are based on heteroskedasticity robust standard errors while the conventional F-tests are not.

In equation (6), finding that μ_{Sales} and μ_{Profit} are not significantly different across countries and/or investment types implies that the long-run investment behavior of firms are the same (across countries and/or investment types).Imposing that η_1, ξ_0, ξ_1, ρ, θ_0, and θ_1 be equal in addition assumes that the investment adjustment process (the short-run behavior) would also be the same.

3 Remarks on Estimation: The Choice of the Within Estimator

The econometric model of the error correction specification (5) or (6) of our investment and R&D equations is the usual linear regression model for panel data with firm effects and time effects:

$$y_{it} = \gamma y_{i,t-1} + x_{it}\beta + \alpha_i + \alpha_t + \varepsilon_{it} \qquad i = 1, ..., N \ ; \ t = 1, ..., T. \tag{7}$$

Note that these regressions are nonlinear in the long run parameters of interest (μ_{Sales} and μ_{Profit}), although linear in the right hand side variables. Moreover, given the estimated linear coefficients, the structural parameters are exactly identified.

We account for the time effects α_t by including a full set of year dummies in all the regressions explicitly.[13] We account for the firm effects α_i by relying mainly on the within firm estimator (or least squares on the deviations of all variables to their firm means, that is implicitly including firm dummies). The advantage of the within estimator relative to the total estimator (or the least squares estimates on the untransformed variables) is that these estimates correct for the biases arising from the correlations between the firm effects and the right hand side variables ($y_{i,t-1}$ and x_{it}) in the regression. Note that the autoregressive formulation of the investment equation implies that such a correlation exists with the lagged endogenous variable ($y_{i,t-1}$) and that such a correlation is also likely for the other variables x_{it}, which are things like the firm's own sales and cash flow.

The within estimator, however, may still suffer from two other types of biases, arising from the possible correlations of the right hand side variables with the past and current values of the idiosyncratic disturbances $\varepsilon_{it}, \varepsilon_{i,t-1}$, $\varepsilon_{i,t-2}, ...$. Correlation with the past values of the disturbances will induce bias via the within transformation if some of the right hand side variables are predetermined rather than strictly exogenous. In our case, of course, at least one ($y_{i,t-1}$) and possibly more of the right hand side variables are

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[13] We have thus included 12 of them. Although our French and U.S. samples period covers the 15 years 1979-1993, the estimation period is restricted to 1982-1993, because of the lagged variables and the choice of the beginning of year capital to measure the investment and cash flow rates.

predetermined endogenous variables. More precisely, in this case the within estimator is biased due to the correlation of $y_{i,t-1}$ and the $x_{it}s$ with the average of past disturbances ($[\varepsilon_{i1+}\varepsilon_{i2}+...+\varepsilon_{i,(t-1)}]/T$), which is a component of the overall period average $\varepsilon_{i.}$ ($= [\varepsilon_{i1+}\varepsilon_{i2} + ... + \varepsilon_{i(T-1)} + \varepsilon_{iT}]/T$); bias of this kind will thus fall and become negligible with the length T of the study period. For a study period of 12 years as ours, this source of bias is indeed small and unlikely to make significant differences.

However, even in the case of fairly large T, it remains true that the within estimator can be biased if some of the x_{it} are *simultaneously* determined with y_{it}, or if some of the x_{it} or $y_{i,t-1}$ are affected by random errors of measurement. In these cases the biases will not go away as the time period being studied increases. Because it seems unlikely that investment rates, output, and profits would not be "simultaneous" to some extent (given our use of annual data) and unlikely also that they would be "perfectly" measured, it is important *a priori* to consider this issue. A solution to this second source of bias (as well as to that arising from the presence of lagged endogenous variables) is to use an instrumental variables (IV) estimation method, where the instruments are an appropriate set of lagged values of the variables. Allowing for the heteroskedasticity of the disturbances across firms and their possible correlation over time, this argues for use of the GMM method of estimation which has been advocated strongly in recent years.

The "first differenced GMM" estimates are based on instrumenting the differenced version of equation (7) by the lagged level-values of the variables. More precisely, under the assumption that the disturbances ε_{it} are not serially correlated, we expect $\Delta\varepsilon_{it} = (\varepsilon_{it} - \varepsilon_{i,t-1})$ to be orthogonal to the past history of the x and y variables (after the first lag), so that $x_{i,t-2}, x_{i,t-3}, \ldots, y_{i,t-2}, y_{i,t-3}, \ldots$ are available as instruments for $\Delta\varepsilon_{it}$.[14] The "system GMM" estimates are based on the idea that if equation (7) is the true model, it is also possible to instrument the untransformed equation, which contains the firm effects α_i's, using the lagged differences of the x's and y's ($\Delta x_{i,t-1}, \Delta x_{i,(t-2)}, \ldots, \Delta y_{i,t-1}, \Delta y_{i,(t-2)}, \ldots$), since these presumably do not contain such firm effects. The "system" GMM combining the two sets of instruments results in estimates which can be much more efficient than the "first-differenced" GMM alone.[15]

In estimation practice, the choice of instruments should satisfy two requirements which tend to go in the opposite direction: the exogeneity or validity of the instruments and their relevance. The validity of instruments is usually verified by the classical Sargan test of the over-identifying restrictions; the Lagrange Multiplier (LM) tests of autocorrelation of errors are also

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[14] If the disturbances ε_{it} follow a moving average process of order one MA(1), the first valid instruments are found at the third lag instead of the second because the differenced disturbances follow an MA(2) process.

[15] See especially Arellano and Bover [1995] and Blundell and Bond [1998].

useful to confirm the exogeneity of the $(t-2)$ or $(t-3)$ lagged instruments.[16] However, even though the instruments may appear to be valid according to these tests, they may be only (very) weakly relevant (i.e., correlated with the instrumented variables).[17] In consequence, the GMM estimators have large standard errors and the parameter estimates are very imprecise. Moreover, this imprecision implies that when doing statistical inference, one is likely to accept the null hypothesis simply because the power of the test is low.

As can be seen in Appendix C, the standard errors of our GMM estimates appear to be very large and we are in a clear case of weak instruments. The system GMM estimates tend to be less imprecise than the first differenced GMM estimates but not much less. As could be expected with such wide standard errors, some of the GMM point estimates have quite implausible magnitudes, and most of them are not in fact statistically different from the within estimates. Based on this evidence, it is not possible to assess the importance of the simultaneity and measurement error biases that seem *a priori* likely to affect our within estimates. A hint that they might not be large is our main finding that the within estimates of the long run parameters of investment behavior are quite close across the two countries and two types of investment, with the major exception of the high and significant cash flow coefficient in the U.S. If these estimates were badly biased, this finding also implies that the consequence of the bias was similar in the two countries, which is not that likely. In any case, our GMM estimates are not meaningful enough (lack power and suffer from small sample/weak instrument bias) to allow for the comparison across country and investment type that we do here, and hence we chose to focus on the within estimates which seemed both more precise and more plausible.

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[16] See Hansen [1982] for the Sargan test and Arellano and Bond [1991] for the autocorrelation test. In practice, one will first test the validity of level instruments for the first-differenced GMM using the corresponding Sargan test, and, conditional on the acceptance of this test, one will then test the validity of the additional differenced instruments for the system GMM using the corresponding "differenced" Sargan test.

[17] On the problem of weak instruments, see for example Nelson and Startz [1990], Staiger and Stock [1997] and Blundell and Bond [1998]. The relevance of the instruments can be assessed by considering the R-squares and F-statistics from the regressions of the instrumented variables in the model on the set of instruments (Nelson and Startz [1990] and Bound, Jaeger, and Baker [1995]). However, this can be misleading because of the intercorrelations between the instrumented variables and Shea [1997] and A.R. Hall, Rudebush, and Wilcox [1996] have suggested computing the canonical correlations between the set of instrumented variables and the set of the instruments, and testing the significance of the smallest of these canonical correlations. We shall not report here on the use of these various diagnostic indicators of the relevance of our GMM instruments, as we have done so in detail in Mairesse, Hall, and Mulkay [1999].

4 The French and U.S. Samples: Descriptive Statistics

Our empirical analysis is conducted on two panel data samples constructed from the balance sheets and income accounts of large French and U.S. Manufacturing firms. The two samples are of approximately the same size, both consisting of about 500 firms for the period 1979-1993, most of which perform R&D continuously during the period (and all of which invest in physical assets every year). We have paid particular attention to obtaining similar definitions of the variables in both countries in spite of differences in accounting schemes; some non negligible discrepancies, however, may remain in the computation of our cash flow or profit rate measures. The data sources and the detailed definitions of the variables used in the analysis are given in Appendix B.

Tables 1 and 2 give the industry composition and the descriptive statistics for the main variables used in the analysis for our French and U.S. samples and for the corresponding subsamples of the R&D firms and the non R&D firms. Figures 1, 2 and 3 represent the yearly evolution of the median values of the main variables for the two samples over the full period 1979-1993. It is interesting to comment briefly on these average or median values of the variables and their evolution. However, one should be aware that our estimation results do not depend in fact on them, since all our regressions include year dummies.

We can see from Table 1 that the proportion of firms in high-technology industries are about the same in France and the U.S. (35%), high-tech industries being those with high R&D investment rates in both countries and where firms are more likely to perform R&D: Computers & Instruments, Drugs, Chemicals, Automobile, and Aircraft & Boat. However, we also note that most of the U.S. firms do R&D during the period, whereas less than half of the French firms do.

In Table 2 we see that the U.S. firms are about ten times larger in average than the French firms in terms of employment in spite of the fact that our samples consist of the largest manufacturing firms in each country for the most part. This is in line with the relative size of the two economies, and also with the fact that the notion of the firm as a legal entity tends to be more broadly determined (at a more consolidated level) in the U.S. than in France. The R&D firms are also larger than the non-R&D firms in both country.

French and U.S. firms exhibit the same median growth rate of sales (Δs) of about 2% per year, but with higher volatility for the U.S. firms. Sales growth is also significantly more rapid for the French R&D firms than for the non-R&D firms (by about 0.5% per year), while it is about the same for U.S. firms.

U.S. firms are likely to invest more in fixed capital than the French firms, with a median investment rate (I/K) and a median investment-to-sales ratio (I/S) both higher by about 2 %, and a median capital stock-to- sales ratio (K/S) higher by about 7 %. The picture seems less clear cut for R&D, with

Table 1. Size of the French and U.S. Samples

FRENCH FIRMS	**All Firms**		**R&D**		**Non-R&D**	
	N[a]	%[b]	N[a]	%[c]	N[a]	%[c]
Computers and Instruments	32	6.6	20	62.5	12	37.5
Drugs	43	8.8	36	83.7	7	16.3
Chemicals	33	6.8	24	72.7	9	27.3
Automobile	37	7.6	26	70.3	11	29.7
Aircraft and Boat	15	3.1	10	66.7	5	33.3
Electrical Machinery	31	6.4	14	45.2	17	54.8
Machinery	41	8.4	22	53.7	19	46.3
Rubber and Plastics	25	5.1	12	48.0	13	52.0
Fabricated Metals	35	7.2	12	34.3	23	65.7
Wood, Paper and Misc.	73	15.0	13	17.8	60	82.2
Primary Metals	15	3.1	7	46.7	8	53.3
Textiles and Leather	65	13.4	7	10.8	58	89.2
Food and Tobacco	41	8.4	11	26.8	30	73.2
TOTAL	**486**	**100.0**	**214**	**44.0**	**272**	**56.0**

U.S. FIRMS	**All Firms**		**R&D**		**Non R&D**	
	N[a]	%[b]	N[a]	%[c]	N[a]	%[c]
Computers and Instruments	73	15.1	72	98.6	1	1.4
Drugs	39	8.1	36	92.3	3	7.7
Chemicals	19	3.9	19	100.0	0	0.0
Automobile	27	5.6	22	81.5	5	18.5
Aircraft and Boat	11	2.3	7	63.6	4	36.4
Electrical Machinery	23	4.8	17	73.9	6	26.1
Machinery	61	12.7	50	82.0	11	18.0
Rubber and Plastics	16	3.3	12	75.0	4	25.0
Fabricated Metals	31	6.4	22	71.0	9	29.0
Wood, Paper and Misc.	90	18.7	41	45.6	49	54.4
Primary Metals	25	5.2	13	52.0	12	48.0
Textiles and Leather	37	7.7	13	35.1	24	64.9
Food and Tobacco	30	6.2	12	40.0	18	60.0
TOTAL	**482**	**100.0**	**336**	**69.7**	**146**	**30.3**

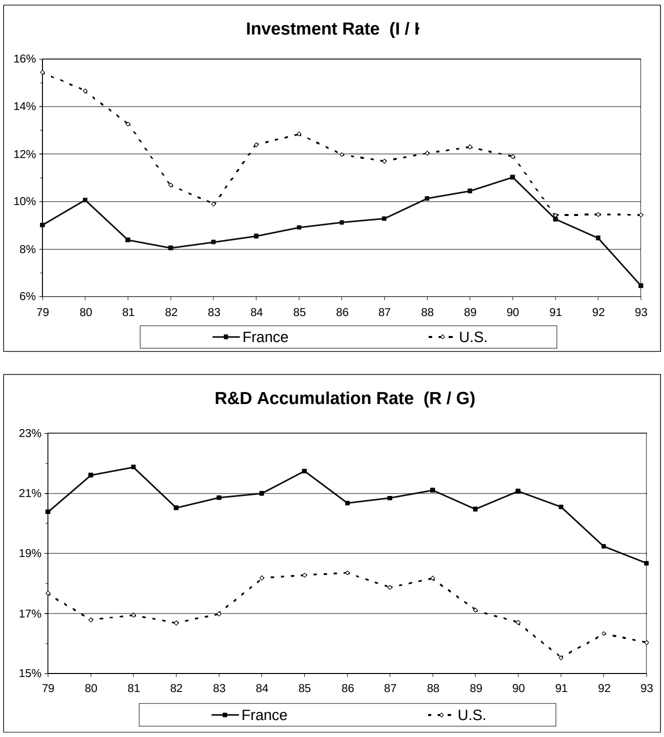
[a] Number of firms.
[b] Percentage of the total number of firms.
[c] Percentage of firms in the considered industry.

Table 2. Decriptive Statistics on the Variables (for the estimation period 1982-1993)

FRENCH FIRMS	**All Firms**			**R&D Firms**		
	Mean	St.Dev.	Median	Mean	St.Dev.	Median
Employment	1 568	5 882	564	2 558	8 263	814
Sales s	740.5	3 356.3	200.0	1 296.3	4 928.3	318.6
Sales Growth Δs	1.81	11.66	1.95	2.25	11.66	2.53
I/K (%)	11.04	9.06	9.00	11.56	9.33	9.36
R/G (%)				26.70	21.21	20.65
I/S (%)	3.86	2.99	3.20	4.12	2.85	3.51
R/S (%)				3.62	4.71	2.01
$\log(K/S)$	0.426	0.234	0.384	0.444	0.239	0.402
$\log(G/S)$				0.171	0.242	0.088
C/K (%)	14.95	16.76	13.37	15.62	15.89	14.28
$\Pi = C/(K+G)$ (%)	13.44	15.40	12.04	12.19	12.31	11.29
$(C+R)/(K+G)$ (%)				15.26	15.55	14.17

U.S. FIRMS	**All Firms**			**R&D Firms**		
	Mean	St.Dev.	Median	Mean	St.Dev.	Median
Employment	19 848	51 544	4 850	24 044	59 938	5 767
Sales s	2 240.0	6 661.1	457.6	2 687.3	7 683.4	570.8
Sales Growth Δs	1.38	14.14	2.00	1.31	14.16	1.95
I/K (%)	13.84	9.95	11.75	14.18	9.87	12.08
R/G (%)				18.30	9.56	17.07
I/S (%)	5.84	4.62	4.70	6.16	4.30	5.10
R/S (%)				3.64	3.94	2.33
$\log(K/S)$	0.499	0.297	0.424	0.518	0.281	0.458
$\log(G/S)$				0.199	0.180	0.144
C/K (%)	25.80	19.98	22.65	27.64	20.55	24.31
$\Pi = C/(K+G)$ (%)	19.83	14.87	18.14	19.06	13.26	17.84
$(C+R)/(K+G)$ (%)				23.84	16.63	21.85

Fig. 1. Investment Rate and R&D Rate (Medians by Year)



a much higher median R&D investment rate (R/G) for the French firms (by about 8%), a median R&D to sales ratio (R/S) about equal in the two countries, and a median capital-to-sales ratio (G/S) a little higher for the U.S.firms (by about 3%). These differences reflect those in the past evolutions of R&D spending by French and U.S. firms. They may be also related in part to the fact that we have a shorter history of R&D for many French firms, and thus to our somewhat arbitrary choice of an initial R&D capital stock benchmark.[18] In both countries R&D firms tend to invest more in physical assets and to be more capital intensive than non R&D firms.

Whether we measure the profit or cash flow rate in the usual way by C/K, by the R&D adjusted measure $(C + RD)/(K + G)$, or, as we do here, with respect to total capital by $\Pi = C/(K + G)$, U.S. firms appear much

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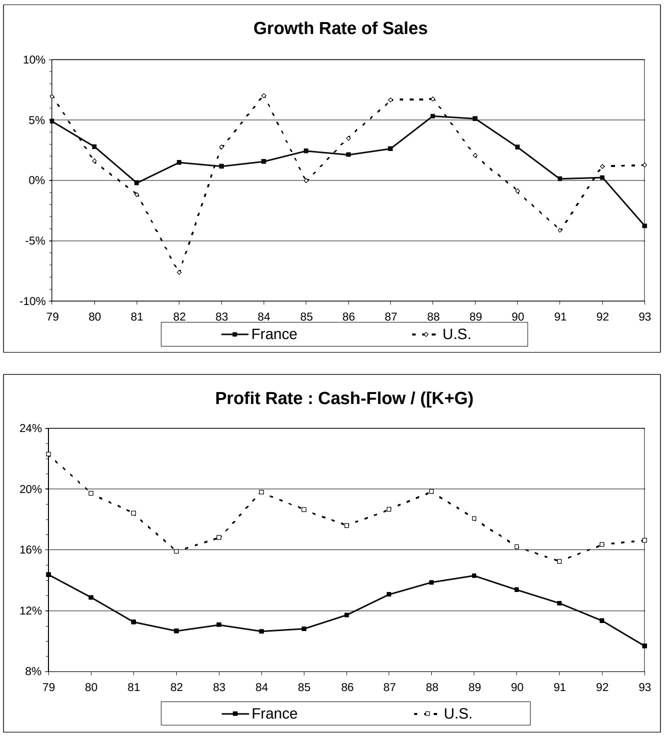
[18] Experimenting with different plausible variants for the choice of these benchmark values did not change much the overall pattern of differences between the two samples of R&D doing French and U.S.firms. We also checked that the choice of the R&D (and investment) benchmark values and that of average depreciation rates had practically no influence on our estimation results.

Fig. 2. Growth Rate and Profit Rate (Medians by Year)



more profitable in average than their French counterparts. The difference may correspond in part to different accounting practices of firms in the two countries, in particular in relation to their pension and other social security legal obligations.

Figures 1, 2 and 3 show some contrasting median evolutions in the main variables for our French and U.S. samples. The median investment rates (I/K) are larger in the U.S. than in France, but they converge towards each other later in the period. The median accumulation rates of R&D (R/G) evolve similarly over time in the two countries; they remain, however, significantly higher for the French firms than for the U.S. firms (about 0.20 and 0.175 respectively). This difference reflects the higher growth rates of R&D in France: the median French firm in our sample had a growth of real R&D of about 5%, whereas the median U.S. firm had a growth rate of 2.5%.

The profit rate ($\Pi = C/(K+G)$) decreases over time in the U.S., starting from a very high level, but always remaining higher than in France, where it follows the business cycle of the eighties.[19] In the U.S., the business cycle is

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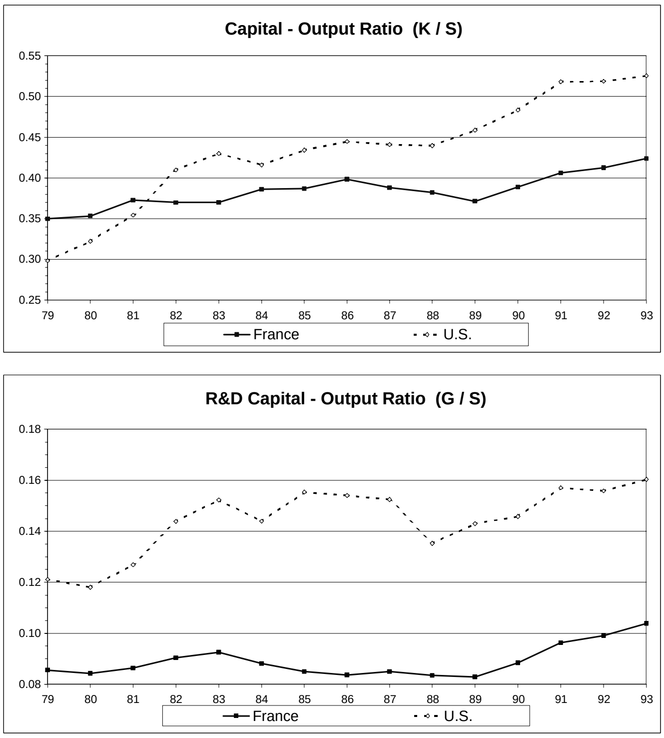
[19] This is also true of the more conventional measure C/K (not shown).

Fig. 3. Capital-Output Ratio (Medians by Year)



more noticeable in the movements of the median growth rate of sales (Δs), with 1982 and 1991 being the two lowest years (with negative growth).

An important difference between the two countries is also the change in the median capital-output ratio (K/S). It has a clear and large rising trend in the U.S. (about 4% per year) as against a much flatter slope in France (about 2%).[20]

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[20] Like in the case of our measure of R&D capital stock, this contrast may to some extent correspond to our choice of initial benchmark values; in both countries we have used as benchmarks the net book values of physical assets in the first year of data for each firm (see Appendix B), which in part reflect some differences in accounting practices (and especially in accounting service lives). Another possible reason may be related to differences in our investment price deflators (see Appendix B); in France the prices of equipment goods (mainly computers and related equipment) in the national accounts have been adjusted for quality change beginning a number of years later than in the U.S. However, this can at best explain a small part of why the capital-output ratio for France increases much less than in the U.S..

5 The Estimation Results: Similarities and Differences between Investment and R&D, and France and the U.S.

Tables 3 through 10 show our main estimation results for the investment and R&D equations written as (5) or equivalently as (6), while Figure 4 provides a summary of the various tests of parameter equality across country and investment type.[21] More precisely, the sequence of eight Tables presents the within firm estimates (with year dummies) of the same overall model for both physical investment and R&D and both countries, going progressively from a fully constrained specification where all the country and investment type parameters are equal, to the unconstrained specification where these parameters can all be different. Tables 3 through 6 give the estimations where the lagged endogenous variable coefficient and the other short run dynamics coefficients are allowed to differ across country and investment type, and Tables 7 and 10 the estimations where the long run parameters (i.e., all structural parameters) are also allowed to differ. In all these specifications, the year dummies are free to vary across country and investment type, and the firm dummies are also varying across investment type, so that our tests concern only the comparison of structural coefficients.

Although our estimation and testing approach is in fact rather straightforward, it may look somewhat complex at first glance. For this reason, we begin by describing the exact layout and logical sequence of our results as shown in the Tables and providing a first look based on figure 4. We then discuss our results more fully, focusing first on what they tell us on the short run dynamics of investment and R&D, and then on the long run effects of sales and profits, and commenting also on the relative variability and correlations of the firm and year effects and idiosyncratic disturbances.

5.1 Overview of results

All the eight Tables displaying our estimation results have a similar format. They consist of one group of one, two or four columns (two groups in the first Table), corresponding to a more or less constrained version of the investment model (labelled (1), (2), (3e), (3c), (4), (5e), (5c), (6) or (7)), and showing the following:

1. The estimated structural coefficients ($\eta_1, \xi_{0,}\xi_1, \rho, \lambda, \theta_0,\theta_1,\theta_2$) of the model, and in parentheses the heteroskedastic-consistent estimates of their standard errors.[22]

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[21] All estimates in the paper were obtained using the software package TSP Version 4.5 (Hall and Cummins [1999]).

[22] The LM test for homoskedasticity of the disturbances strongly rejects the null hypothesis.

2. The estimated long-run sales and cash flow coefficients μ_{Sales} and μ_{Profit} (equal to $(1 - \lambda/\rho)$ and $(-(\theta_0 + \theta_1 + \theta_2)/\rho)$, and in parentheses the heteroskedastic-consistent error estimates of their standard errors.[23]
3. The sum of squared residuals, standard error of the regression, and the adjusted R-squared, computed in the conventional manner.
4. A chi-squared test (test value, degree of freedom and p-value) for the hypothesis that the version of the model considered (in the given Table and group of columns) is the same as a more constrained version (in a previous Table). This is the robust version of the Wald test based on the heteroskedastic-consistent standard errors.[24]

The nine versions of the investment model considered are the following:

- (1) - All the structural coefficients are assumed to be the same across investment type and country.
- (2) - The same as (1), but with the coefficient of the lagged endogenous variable (η_1) allowed to vary across investment type. This appears to be the single most important constraint in our estimations and we therefore let this coefficient be free to differ between physical investment and R&D in all versions other than (1).
- (3e,3c) - The same as (2), but with all the short run coefficients allowed to vary across investment type (3e) or country (3c). All the long run coefficients are constrained to be equal (which implies that we estimate our model as equation (6)).
- (5e,5c) - The same as (2), but with all the coefficients (short run and long run) allowed to vary across investment type (5e) or country (5c).
- (6) - The same as (2), but with all the short run coefficients allowed to vary by investment type and country, and with only the long run profit coefficient allowed to differ by country. This is our preferred specification which was arrived at after looking at several alternative hypotheses about the long run coefficients (assuming various patterns of differences in the long run coefficients of both profit and sales across investment type and country).
- (7) - The same as (6), but with all coefficients (short and long run) allowed to differ across investment type and country.

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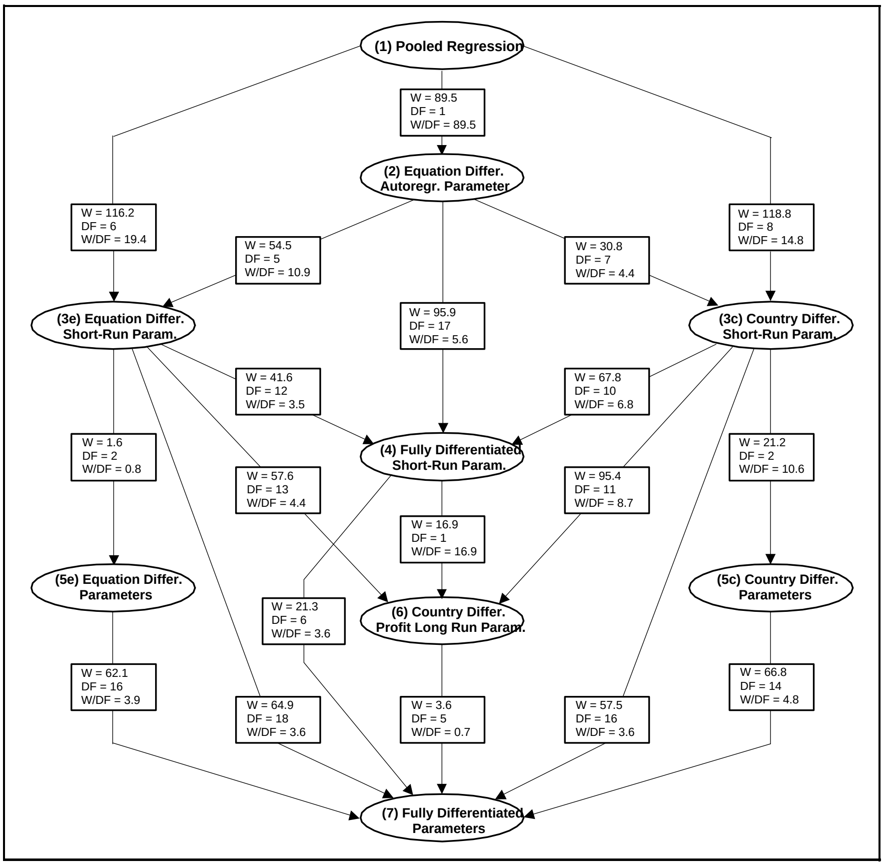
[23] For the sake of completeness, we also show the corresponding estimated coefficients of the last lag (lag 2) of sales and the profits ratio (ξ_1 and θ_2). These have not been estimated, but are derived from the long run coefficients using the delta method to obtain the standard errors.

[24] We do not show in the tables the panel version of the Durbin-Watson statistic for the test of serial independance of the disturbances ε_{it}, but in all cases this statistic was equal to about 1.85. Given our very large sample size this value is statistically significant at conventional levels of confidence; it implies, however, a very low serial correlation (less than 0.1), thus justifying the choice of an ADL(2,2) specification to model the short run investment dynamics parsimoniously.

Fig. 4. Wald Tests of Parameter Equality



W = Wald Test (based on heteroskedastic-consistent covariance matrix of estimates)
DF = Degrees of Freedom
W/DF = Wald test statistics divided by its degrees of freedom.

Figure 4 presents a summary chart of the Wald tests of parameter equality in the nine versions of model, when moving from one version to a next one in which it is nested. Because our sample size is quite large, all the tests fail to accept the null hypothesis of equality at the conventional levels of statistical significance. However, when we focus instead on the values of the chi-squared per degree of freedom (given as WDF=W/DF in each box of the Figure), which provide a rough and ready yardstick of how much the equality constraints "matter", some interesting patterns emerge.

By far the most important constraint that appears on the chart is to impose that investment and R&D have the same lag coefficient (η_1). As is by now well-known, R&D investment rates are much more highly serially correlated (from year to year) than ordinary investment rates, even when firm effects are controlled for. This reflects the intertemporal nature of the R&D investment process and the fact that more than half the cost is the wages and salaries of trained scientists and engineers, whose productivity would be badly hurt by short-term hiring and firing. Hence our finding of a stronger tendency for the firm to smooth its R&D spending than its ordinary capital investment. This is true in both France and the U.S., although somewhat more true in the U.S. (with a lag coefficient of R&D of about 0.35 versus 0.25 in France). Because of the extreme significance of this constraint, we relaxed it in all of the other model versions (other than (1)), even for those in which otherwise the coefficients are differentiated only across country.

The second most important constraint on the chart is that the long run coefficient of profits (μ_{Profit}) be the same in both countries (moving from model (4) to model (6)). In contrast, moving from model (6) to model (7), where we allow the long run coefficients for both sales and profit to differ across countries and investment type costs us much less in terms of chi-squared units per degrees of freedom. The other constraints which appear to matter next are clearly related to the other short run coefficients (besides η_1), and not the other long run coefficients (other than μ_{Profit} by type of investment). These are the reasons why we finally chose model (6) as our preferred specification.

5.2 Short run dynamics

Table 3 reveals several stylized facts that are qualitatively true throughout all the following tables. First, the accelerator appears to be alive and well, with a substantial contemporaneous and lagged relationship between sales growth and both investment rates. The relationship is approximately the same for France and the U.S., but differs somewhat across investment type and a weaker response for R&D than for investment (with a current coefficient of about 0.09 as against 0.16, and a lagged coefficient of about 0.05 as against 0.09).

Second, the error correction term is negative as expected, and approximately equal to -0.14, meaning that a given output-capital gap is being closed via investment at a rate of 14 percent per year. When this parameter is allowed to differ across investment types (models 3e and higher), the gap closes up faster for ordinary capital (at a rate of about 16 percent) than for R&D capital (at a rate of about 10 percent).

Third, in contrast to the sales growth impact which is strongest contemporaneously, the profit variable affects both types of investment with a lag. The coefficient of about 0.08 implies that a change in the profit rate from, for example, 15 percent to 20 percent, is followed one year later by a modest increase in both investment rates of approximately 0.4 percent. In this case also, the effect tends to be (very slightly) lower for R&D than for ordinary investment.

Table 3. Estimation Results : Models (1) and (2)

	(1) **Pooled Equation**	**(2)** **First Autoregressive Parameter Differentiated by Type of Investment**	
		Investment	R&D
Number of Parameters	56	57	
I_{t-1}/K_{t-2} or R_{t-1}/G_{t-2}	0.124	0.046	0.284
	(.014)	*(.014)*	*(.024)*
Δs_t	0.136	0.138	
	(.007)	*(.007)*	
Δs_{t-1}	0.073	0.074	
	(.006)	*(.006)*	
$(k-s)_{t-2}$ or $(g-s)_{t-2}$	-0.142	-0.132	
	(.006)	*(.006)*	
s_{t-2}	-0.041	-0.038	
	(.004)	*(.004)*	
Π_t	-0.012	-0.017	
	(.011)	*(.010)*	
Π_{t-1}	0.084	0.088	
	(.010)	*(.010)*	
Π_{t-2}	0.007	0.015	
	(.009)	*(.009)*	
Long Run Sales	0.712	0.714	
	(.027)	*(.028)*	
Long-Run Cash-Flow	0.557	0.646	
	(.096)	*(.107)*	
Sum of squared residuals	75.481	74.160	
Standard error of regression	0.0688	0.0682	
Adjusted R-squared	0.544	0.552	
Wald-test [D.F.] (p-value)		(2) vs (1) : 89.5 [1] (.000)	

17540 Observations - Investment Equation : 5 832 for France,
5 784 for the U.S. - R&D Equation : 2 028 for France, 3 896 for the U.S.
1518 Firms - Investment Equation : 486 for France, 482 for the U.S.
- R&D Equation : 214 for France, 336 for the U.S.
Estimation period 1982-1993.
The Wald-test is for the hypothesis that the equations are the same.
Heteroskedastic-consistent standard errors in parenthesis.
All equations include a full set of time dummies.
Numbers shown in parenthesis at the head of column correspond
to the model numbers in Figure 4.

Table 4. Estimation Results : Model (3e)

	(3e) **Short-Run Parameters Differentiated by Type of Investment**	
	Investment	R&D
Number of Parameters	62	
I_{t-1}/K_{t-2} or R_{t-1}/G_{t-2}	0.020	0.329
	(.015)	*(.028)*
Δs_t	0.164	0.093
	(.010)	*(.010)*
Δs_{t-1}	0.092	0.052
	(.008)	*(.010)*
$(k-s)_{t-2}$ or $(g-s)_{t-2}$	-0.164	-0.106
	(.005)	*(.008)*
s_{t-2}	-0.048	-0.031
	(.012)	*(.004)*
Π_t	-0.029	0.003
	(.012)	*(.016)*
Π_{t-1}	0.087	0.079
	(.012)	*(.017)*
Π_{t-2}	0.024	-0.029
	(.011)	*(.014)*
Long Run Sales	0.709	
	(.025)	
Long-Run Cash-Flow	0.494	
	(.089)	
Sum of squared residuals	73.513	
Standard error of regression	0.0679	
Adjusted R-squared	0.556	
Wald-test [D.F.] (p-value)	(3e) vs (2) : 54.5 [5] (.000)	

See Remarks in Table 3.

Table 5. Estimation Results : Model (3c)

	(3c) **Short-Run Parameters Differentiated by Country**			
	FRANCE		U.S.	
	Investment	R&D	Investment	R&D
Number of Parameters	64			
I_{t-1}/K_{t-2} or R_{t-1}/G_{t-2}	0.059	0.232	0.037	0.337
	(.020)	(.029)	*(.020)*	*(.036)*
Δs_t	0.143		0.133	
	(.012)		*(.008)*	
Δs_{t-1}	0.089		0.062	
	(.010)		*(.007)*	
$(k-s)_{t-2}$ or $(g-s)_{t-2}$	-0.139		-0.130	
	(.009)		*(.007)*	
s_{t-2}	-0.040		-0.037	
	(.005)		*(.004)*	
Π_t	-0.039		0.007	
	(.015)		*(.012)*	
Π_{t-1}	0.075		0.101	
	(.015)		*(.012)*	
Π_{t-2}	0.048		-0.029	
	(.013)		*(.012)*	
Long Run Sales	0.713			
	(.028)			
Long-Run Cash-Flow	0.610			
	(.103)			
Sum of squared residuals	73.865			
Standard error of regression	0.0680			
Adjusted R-squared	0.554			
Wald-test [D.F.] (p-value)	(3c) vs (2) : 30.8 [7] (.000)			

See Remarks in Table 3.

Table 6. Estimation Results : Model (4)

	(4)			
	Short-Run Parameters Differentiated by Country and by Type of Investment			
	FRANCE		U.S.	
	Investment	R&D	Investment	R&D
Number of Parameters	64			
I_{t-1}/K_{t-2} or R_{t-1}/G_{t-2}	0.053	0.246	-0.010	0.392
	(.021)	(.033)	*(.021)*	*(.041)*
Δs_t	0.164	0.073	0.162	0.101
	(.015)	*(.016)*	*(.012)*	*(.012)*
Δs_{t-1}	0.096	0.068	0.085	0.042
	(.012)	*(.016)*	*(.010)*	*(.010)*
$(k-s)_{t-2}$ or $(g-s)_{t-2}$	-0.149	-0.131	-0.179	-0.095
	(.011)	*(.013)*	*(.010)*	*(.010)*
s_{t-2}	-0.044	-0.039	-0.053	-0.028
	(.005)	*(.005)*	*(.006)*	*(.004)*
Π_t	-0.047	-0.016	-0.005	0.015
	(.016)	*(.026)*	*(.015)*	*(.021)*
Π_{t-1}	0.075	0.063	0.107	0.084
	(.016)	*(.033)*	*(.015)*	*(.020)*
Π_{t-2}	0.047	0.019	-0.013	-0.050
	(.014)	*(.025)*	*(.016)*	*(.017)*
Long Run Sales		0.704		
		(.025)		
Long-Run Cash-Flow		0.504		
		(.089)		
Sum of squared residuals		73.111		
Standard error of regression		0.0677		
Adjusted R-squared		0.558		
Wald-test [D.F.] (p-value)	(4) vs (3e) : 41.6 [12] (.000)			
	(4) vs (3c) : 67.8 [10] (.000)			

See Remarks in Table 3.

Table 7. Estimation Results : Model (5e)

	(5e)	
	All Parameters Differentiated by Type of Investment	
	Investment	R&D
Number of Parameters	64	
I_{t-1}/K_{t-2} or R_{t-1}/G_{t-2}	0.020	0.329
	(.015)	*(.028)*
Δs_t	0.163	0.093
	(.010)	*(.010)*
Δs_{t-1}	0.090	0.052
	(.008)	*(.010)*
$(k-s)_{t-2}$ or $(g-s)_{t-2}$	-0.165	-0.106
	(.008)	*(.008)*
s_{t-2}	-0.050	-0.031
	(.006)	*(.004)*
Π_t	-0.029	0.003
	(.012)	*(.016)*
Π_{t-1}	0.087	0.079
	(.012)	*(.017)*
Π_{t-2}	0.025	-0.029
	(.011)	*(.014)*
Long Run Sales	0.695	0.776
	(.028)	*(.058)*
Long-Run Cash-Flow	0.502	0.415
	(.095)	*(.259)*
Sum of squared residuals	73.503	
Standard error of regression	0.0679	
Adjusted R-squared	0.556	
Wald-test [D.F.] (p-value)	(5e) vs (3e) : 1.6 [2] (.453)	
Wald-test for LR Sales	1.6 [1] (.209)	
Wald-test for LR Cash-Flow	0.1 [1] (.753)	

See Remarks in Table 3.

Table 8. Estimation Results : Model (5c)

	(5c)			
	All Parameters Differentiated by Country			
	FRANCE		U.S.	
	Investment	R&D	Investment	R&D
Number of Parameters	66			
I_{t-1}/K_{t-2} or R_{t-1}/G_{t-2}	0.059	0.216	0.033	0.334
	(.020)	*(.029)*	*(.020)*	*(.036)*
Δs_t	0.147		0.127	
	(.013)		*(.009)*	
Δs_{t-1}	0.096		0.052	
	(.011)		*(.008)*	
$(k-s)_{t-2}$ or $(g-s)_{t-2}$	-0.151		-0.117	
	(.010)		*(.008)*	
s_{t-2}	-0.046		-0.034	
	(.007)		*(.005)*	
Π_t	-0.059		0.033	
	(.015)		*(.014)*	
Π_{t-1}	0.064		0.120	
	(.015)		*(.013)*	
Π_{t-2}	0.028		-0.004	
	(.013)		*(.013)*	
Long Run Sales	0.695		0.704	
	(.040)		*(.041)*	
Long-Run Cash-Flow	0.220		1.278	
	(.104)		*(.215)*	
Sum of squared residuals	73.601			
Standard error of regression	0.0679			
Adjusted R-squared	0.555			
Wald-test [D.F.] (p-value)	(5c) vs (3c) : 21.2 [2] (.000)			
Wald-test for LR Sales	0.0 [1] (.865)			
Wald-test for LR Cash-Flow	19.6 [1] (.000)			

See Remarks in Table 3.

Table 9. Estimation Results : Model (6)

	(6) **All Parameters Differentiated by Country and by Type of Investment, Except Long-Run Coefficients**			
	FRANCE		U.S.	
	Investment	R&D	Investment	R&D
Number of Parameters	75			
I_{t-1}/K_{t-2} or R_{t-1}/G_{t-2}	0.052	0.241	-0.009	0.387
	(.021)	*(.034)*	*(.021)*	*(.041)*
Δs_t	0.169	0.076	0.155	0.098
	(.015)	*(.016)*	*(.012)*	*(.012)*
Δs_{t-1}	0.104	0.073	0.075	0.037
	(.012)	*(.016)*	*(.010)*	*(.010)*
$(k-s)_{t-2}$ or $(g-s)_{t-2}$	-0.161	-0.137	-0.161	-0.091
	(.012)	*(.013)*	*(.010)*	*(.010)*
s_{t-2}	-0.049	-0.041	-0.049	-0.028
	(.006)	*(.006)*	*(.006)*	*(.004)*
Π_t	-0.064	-0.034	0.017	0.030
	(.017)	*(.026)*	*(.016)*	*(.022)*
Π_{t-1}	0.065	0.056	0.124	0.093
	(.016)	*(.033)*	*(.015)*	*(.020)*
Π_{t-2}	0.030	0.005	0.010	-0.038
	(.014)	*(.025)*	*(.017)*	*(.017)*
Long Run Sales	0.697			
	(.026)			
Long-Run Cash-Flow	0.192		0.939	
	(.098)		(.156)	
Sum of squared residuals	72.946			
Standard error of regression	0.0676			
Adjusted R-squared	0.559			
Wald-test [D.F.] (p-value)	(6) vs (3e) : 57.6 [13] (.000)			
	(6) vs (3c) : 95.4 [11] (.000)			
Wald-test for LR Cash-Flow	16.9 [1] (.000)			

See Remarks in Table 3.

Table 10. Estimation Results : Model (7)

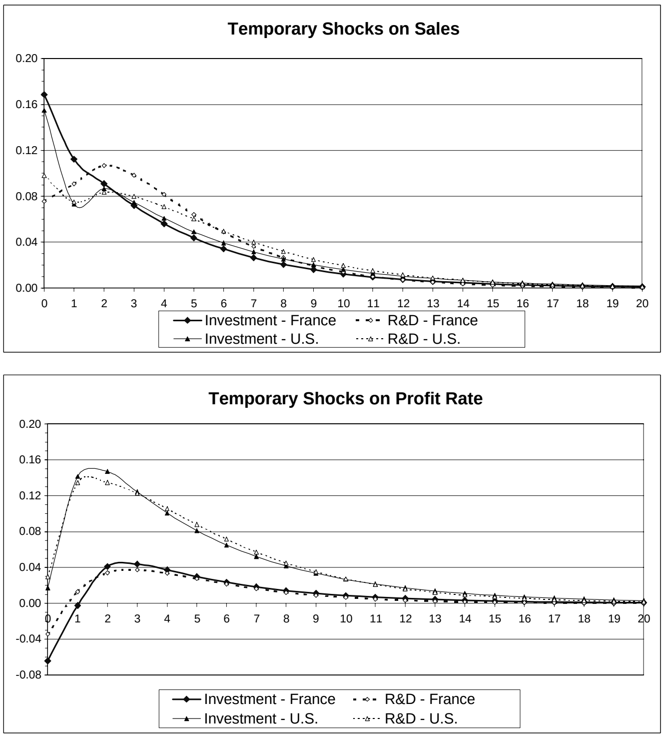
	(7)			
	All Parameters Differentiated by Country and by Type of Investment			
	FRANCE		U.S.	
	Investment	R&D	Investment	R&D
Number of Parameters	80			
I_{t-1}/K_{t-2} or R_{t-1}/G_{t-2}	0.052	0.240	-0.008	0.387
	(.021)	(.035)	*(.021)*	*(.042)*
Δs_t	0.169	0.075	0.152	0.106
	(.016)	*(.017)*	*(.012)*	*(.012)*
Δs_{t-1}	0.104	0.073	0.071	0.047
	(.013)	*(.017)*	*(.010)*	*(.012)*
$(k-s)_{t-2}$ or $(g-s)_{t-2}$	-0.160	-0.138	-0.158	-0.094
	(.013)	*(.015)*	*(.011)*	*(.011)*
s_{t-2}	-0.048	-0.045	-0.051	-0.019
	(.008)	*(.014)*	*(.008)*	*(.007)*
Π_t	-0.063	-0.042	0.021	0.016
	(.017)	*(.030)*	*(.016)*	*(.027)*
Π_{t-1}	0.066	0.052	0.127	0.083
	(.017)	*(.033)*	*(.015)*	*(.022)*
Π_{t-2}	0.031	0.000	0.014	-0.054
	(.014)	*(.029)*	*(.017)*	*(.019)*
Long Run Sales	0.704	0.673	0.678	0.802
	(.044)	(.084)	(.037)	(.078)
Long-Run Cash-Flow	0.206	0.070	1.030	0.481
	(.109)	(.244)	(.070)	(.398)
Sum of squared residuals	72.920			
Standard error of regression	0.0676			
Adjusted R-squared	0.559			
Wald-test [D.F.] (p-value)	(7) vs (6) : 3.6 [5] (.608)			
Wald-test for LR Sales	2.2 [3] (.532)			
Wald-test for LR Cash-Flow	18.7 [3] (.000)			

See Remarks in Table 3.

Overall considering the country differences (models 3c, and higher), it appears that the responses to both sales and profit shocks are rather close, with a slightly faster response of both kinds of investment to profit in the U.S. than in France. In contrast, the investment type differences (models 2, 3e and higher) are much more pronounced. In particular, as we stressed earlier, the investment rates are much smoother (or more inert in their responses to shocks) for R&D than for ordinary investment (and also somewhat smoother for R&D in the U.S. than in France).

Figure 5 illustrates our observations on the short run responses of investment to sales and profits, by showing the different time profiles of the effects of temporary shocks to sales (top panel) and profits (bottom panel) on investment and R&D in both countries, computed using the estimated coefficients from our preferred specification, model (6).

Fig. 5. Effects of Temporary Shocks



For a temporary shock in sales, the four curves in Figure 5 are fairly similar, but with R&D investment in both countries responding more slowly and with a peak at about two years after the shock. It takes about seven years for the impact of the shock to subside to half its initial level in the case of R&D, but only about 2-3 years in the case of ordinary investment.

Contrary to what we see for sales, the response to a temporary shock in the profit rate differs strikingly across countries, but looks very similar for R&D and for investment. For the U.S., the impact is initially quite small and peaks rapidly about 1-2 years after the shock, with an half-life after the peak of about 4 years. For France, on the other hand, the impact is at first slightly negative, and then rises to a peak 2-3 year after the shock, with a half-life of 5-6 years. We can thus conclude that both R&D and investment respond more slowly to transitory shocks to profitability for French firms than for U.S. firms , while no such distinction is apparent in a case of shocks to sales growth. As we shall see now, this conclusion is paralleled by what we find for the long run effects of sales and profits and the time profiles of the effects of permanent shocks.

5.3 Long run effects

Focusing on Tables 9 and 10 which present the estimates of the versions (6) and (7) of our model and the corresponding Wald tests, we see clearly that the long run sales coefficients do not differ significantly by investment type or by country, while the long run profit coefficient differs by country and not by investment type. The test for equality of the four sales coefficients μ_{sales} easily passes, with a chi-squared of 2.2 for 3 degrees of freedom. The test of equality of the four profit coefficients μ_{profit} is strongly rejected, with a chi-squared of 18.7 for 3 degrees of freedom, but this is only because of the difference across France and the U.S. (and not that between R&D and investment).[25]

These results are consistent with the time profiles of the effects of permanent shocks to sales (top panel) and profits (bottom panel) on investment and R&D in France and the U.S., shown in Figure 6 (and computed as in Figure 5 on the basis of the estimated coefficients for model (6)).

Although R&D in France and the U.S. responds slightly more slowly to a permanent shock in sales than investment, they both reach the same level

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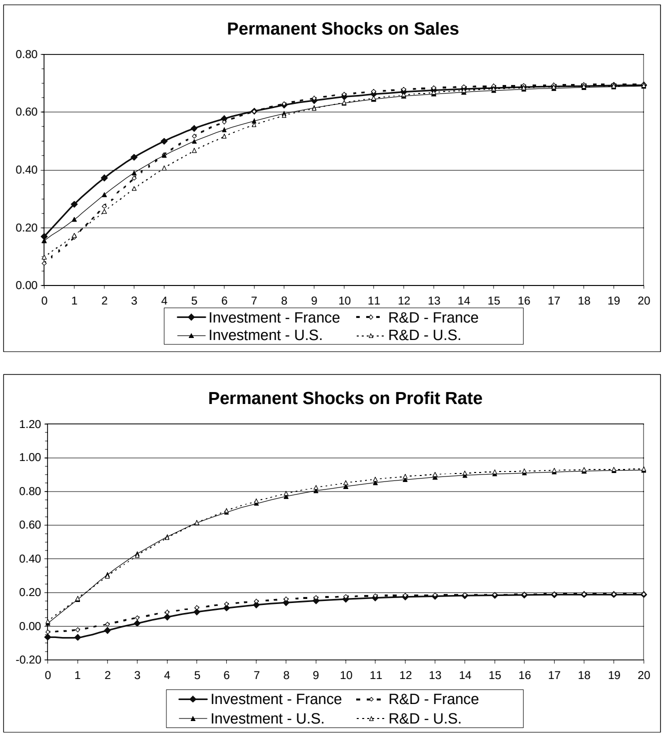
[25] Note that the long run profit coefficients for R&D are very unprecisely estimated (in model (7)), in particular for the U.S., and that we could not in fact statistically reject that they might be equal in the two countries. By contrast these coefficients are precisely estimated for investment, and their equality is indeed strongly rejected across the countries (with a chi-squared of 16.1 for 1 degree of freedom). Since we cannot reject that these coefficients are also equal for R&D and investment within each country, we have a clear problem of transitivity in the tests. We thought more plausible to maintain the assumption of equality across type of investment and the difference across country, that is model (6), rather than another model where we would have maintained the equality across type of investment only for France (not the U.S.) and the difference across country only for investment (not R&D). However, based solely on the present statistical evidence, this latter choice was also possible.

Fig. 6. Effects of Permanent Shocks



of 0.6 in about 7-8 years, and ultimately (in about 14 years) the long run accelerator level of 0.7 (as implied by model (6)). By contrast the response of the two types of investment to a permanent shock in profit, while being about the same for the two types of investment in each country, reaches a much higher level in the U.S. than in France (about 0.9 compared to 0.2). The response of investment and R&D to the profit shock is also much faster for U.S. firms, reaching half its final level in 3-4 years, as opposed to 5-6 years for the French firms.

Bringing together the results on the short and long run, we have fairly strong evidence that the main differences between the two countries lie in the responses of investment and R&D to transitory and permanent profit or cash flow shocks: in both cases the response is more immediate and ultimately much higher in the United States than in France. In contrast to this result, the response to transitory and permanent sales shocks in both countries is similar for the two kinds of investments. We discuss the interpretation of these findings in the concluding section of this paper.

5.4 Firm and year effects and idiosyncratic disturbances

All of our estimating equations include firm and year dummies (α_i and α_t) which are allowed to differ across the two countries and types of investment and can be viewed as capturing the systematic individual and time heterogeneity unexplained in our model. It is thus of interest to consider their relative dispersion and that of the idiosyncratic disturbances (ε_{it}) and also compute their correlations between types of investment (within the two countries). These statistics are shown in Tables 11 and 12.

Table 11. Standard-Deviation of Firm and Year Effects and Idiosyncratic Disturbances, Based on Model (6)

	FRANCE		**U.S.**	
	Investment	R&D	Investment	R&D
Time	0.0099	0.0054	0.0132	0.0057
Individual	0.1035	0.1544	0.1404	0.0992
Idiosyncratic	0.0682	0.0596	0.0682	0.0549
I/K or R/G	0.0882	0.1113	0.0926	0.0953

More precisely, for each investment-country combination Table 11 gives the standard deviation of the year (time) effects, the standard deviation of the estimated firm (individual) effects, the standard deviation of the unexplained (idiosyncratic or within firm and year) residual, and the total standard deviation of the investment rate (the dependent variable). The (untransformed) investment rates all have a standard deviation of around 10 percent, and our model reduces this number to 7 percent for investment (R-squared of about 0.5) and 5.5 percent for R&D (R-squared of about 0.7). Most of the reduction in variance is due to the firm effects themselves, which have a variance higher than that of the raw investment rates, and a negligible amount is contributed by the year effects.

In Table 12, we see that the correlation between the estimated firm effects for R&D and investment is quite high for the U.S. (about 0.5), which is what we expect if these effects are proxies for unobservable (omitted) firm characteristics influencing both types of investment. However, this correlation is quite a bit smaller for France (about 0.2), a finding for which we have no ready explanation. The correlations between the year effects are small for the two countries (even negative for the U.S.), implying that the macro-shocks affecting R&D and investment are largely independent of each other. The same observation is also true for the the idiosyncratic shocks on R&D and investment, which appear to be largely unrelated in both countries.

Table 12. Correlation between the Firm and Year Effects and Idiosyncratic Disturbances for Investment and R&D, Based on Model (6)

	FRANCE	**U.S.**
Time	0.159	-0.115
Individual	0.205	0.552
Idiosyncratic	0.106	0.081
I/K with R/G	0.230	0.355

6 Concluding Remarks

From our plethora of estimation results, some strong stylized facts seem to emerge, which confirm to a large extent some of our earlier work on investment in France and the United States (Mairesse and Hall [1996], Hall, Mairesse, Branstetter, and Crépon [1999], Mairesse, Hall and Mulkay [1999]). When we look carefully at how the investment relation differs across country and across type of investment, using samples of firms and variables that are as comparable as we can make them, we find more similarities than differences overall. This finding, in particular that for the demand or sales accelerator, may be our most striking result. However, we observe also that the greater importance of profit or cash flow in the investment decisions of large U.S. manufacturing firms is confirmed, and that this is probably as true of R&D as it is of investment.[26] That is, the one difference that stands out from these results is that cash flow matters for the investment of U.S. firms and not of French firms, at least during the 1982-1993 period.[27]

When taken together with the evidence that the short run adjustment to sales and profits shocks is generally somewhat slower for French firms

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[26] In an earlier version of this paper, we also showed that it was true for Low-tech as well as High-tech firms.

[27] However, we note that in the case of the U.S. this particular finding, although consistent with those in Mairesse and Hall [1996] and Hall, Mairesse, Branstetter and Crépon [1999], differs somewhat from the results in Mairesse, Hall, and Mulkay [1999], which uses basically the same data, but on a shorter estimation period. In this latter paper, we found that although cash flow entered the investment equation with a long run coefficient near 0.7 in the within estimation (for the period 1985-1993), the long run coefficient was insignificantly different from zero in the first differenced GMM estimates. In Appendix C of this paper we display the GMM estimates (both first differenced and system GMM) for the current dataset and period (1982-1993). They are very imprecise, with huge standard errors on the long run cash flow coefficient (of about 2.7 and 2.0 respectively !), but the coefficient itself is quite positive (contrary to our previous finding). Thus we have concluded that the balance of the evidence suggests a strong cash flow effect, but we caution that this conclusion carries with it much uncertainty.

than for U.S. firms, we believe that this finding points to real differences between the workings of the capital markets in the two countries. As we and others have argued in the past, during this period at least, the typical U.S. shareholder had a somewhat smaller ownership share and was somewhat more likely to sell his shares than his or her French counterpart. This type of market discipline may indeed lead to a more rapid responsiveness on the part of U.S. firms to news about their prospects, and may also make them more sensitive to cash flow shocks when making investment plans. To the extent that they feel pressure to use internal funds to finance future spending, they will have a higher long run response to surprises in profits (not accompanied by surprises in demand) than would otherwise be the case.[28]

In discussion, Colin Mayer suggested that it was possible that cash flow shocks in the U.S. are a better predictor of future profitability in the U.S. than in France. If this were the case, then one would expect indeed more responsiveness by the U.S. firms than by the French firms to a shock of this kind, since they would perceive the signal as stronger about the future. We have checked this explanation of our finding, which seemed to us plausible, by examining the autocorrelations of the cash flow-capital ratio in the two countries, both between and within firms. Figure 7 thus plots the autocorrelation functions for the cash-flow-capital stock ratio in levels, within-firm and in first difference, and for the sake of comparison Figure 8 does the same for the log sales. Although cash flow is somewhat more persistent in the levels in U.S. firms (with a first autocorrelation of 0.83 versus 0.76 for France), there is no evidence of any difference between the two countries in the correlation of cash flow changes: the first autocorrelation is slightly negative (-0.2) and the rest are zero in both countries. This contradicts the argument that cash flow shocks are a better signal in the U.S. than in France so we must look elsewhere for explanations of our finding.

A second difference between R&D and ordinary investment in our results is already well known for the United States, but less so for France: the fact that R&D spending tends to be more strongly smoothed than investment at the firm level. This implies a slower adjustment process to shocks in sales, whether temporary or permanent, for R&D than for investment, which is indeed what we see in both countries. However, in the case of *cash flow* shocks we also observe that the pattern of R&D and investment response is quite similar in both countries. Might such difference in response to sales and cash flow reflect the difference in response to demand and liquidity shocks to some extent? That is, R&D spending plans typically involve a mix of projects, each of which runs over several years, so that the response to demand shock might involve revisions to spending and the undertaking of additional projects (or cancelling of current projects, both of which take time and would perhaps

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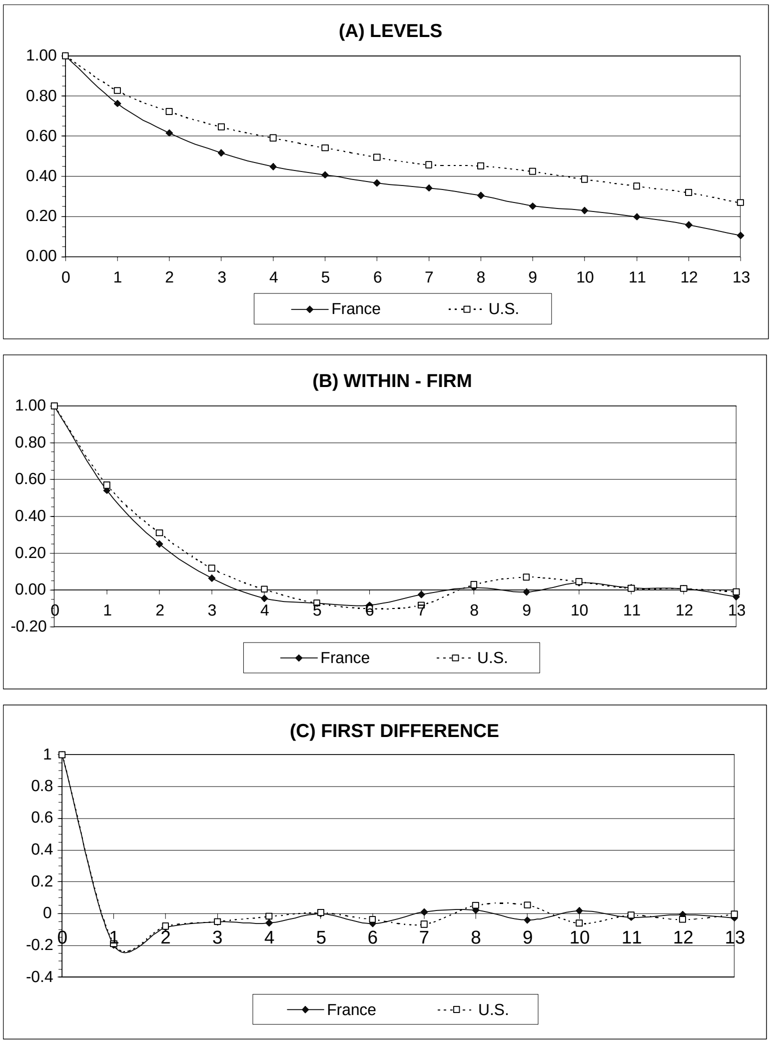
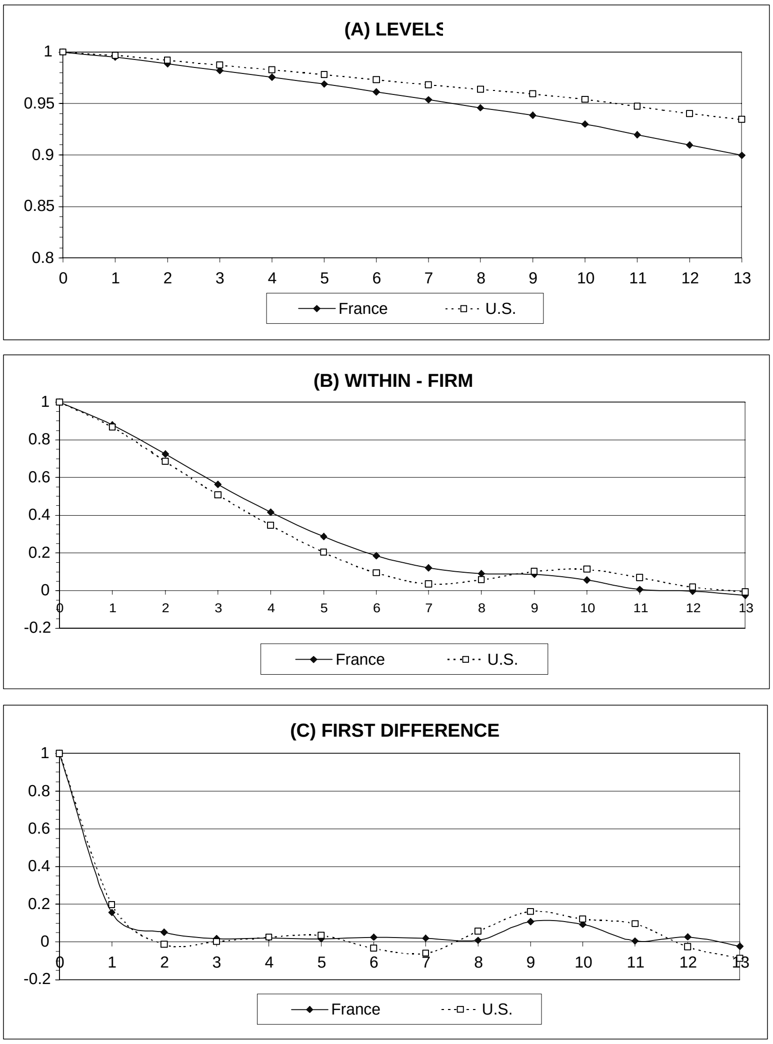
[28] However, this last conclusion may be tempered with the observation that it appears that in our samples the French firms are financing as much investment and R&D out of current retained profits as the U.S. firms, at least at the median.

Fig. 7. Autocorrelations : Profit Rate



be spread over several time periods. On the other hand, cash flow shocks (either negative or positive) will impact existing R&D plans rather quickly if the firms are relying on internal funds for financing these plans, leading to immediate adjustments by slowing or speeding upexisting projects slightly. We offer this interpretation as an area of discussion and further investigation rather than as a firm conclusion.

Fig. 8. Autocorrelations : Sales



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Appendix A: The Accelerator Profit Model

Starting with equation (3), with cash flow terms added and using the investment ratio as a proxy for the net growth rate of capital stock (see **??**), we obtain the following accelerator-profit model (APM) for investment:

$$\begin{aligned} \frac{I_{it}}{K_{i,t-1}} = {} & d_t + \gamma_1 \frac{I_{i,t-1}}{K_{i,t-2}} + \gamma_2 \frac{I_{i,t-2}}{K_{i,t-3}} \\ & + \beta_0 \Delta s_{it} + \beta_1 \Delta s_{it-1} + \beta_2 \Delta s_{it-2} + \\ & \theta_0 \Pi_{it} + \theta_1 \Pi_{i,t-1} + \theta_2 \Pi_{i,t-2} + \Delta \varepsilon_{it} \end{aligned} \tag{8}$$

Note that the firm-specific effects α_i have been removed by this differentiation, and the time dummies $d_t = \Delta\alpha_t$.[29] Note also that if we assume that the disturbances ε_{it} in the level specification follow a white-noise process,

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[29] The alert reader will note that the depreciation rate δ remains in principle a source of additive differences across firms in the equation, even after differentiation, due to the use of the gross investment rate I/K rather than the net rate Δk $(= I/K - \delta)$.

the disturbances $\Delta\varepsilon_{it}$ in the first-differenced accelerator-profit model follow MA(1) process.

In this specification, the long run effects of sales or profits are obtained as:

$$\mu_{Sales}^{INV} = \frac{\beta_0 + \beta_1 + \beta_2}{1 - \gamma_1 - \gamma_2} \qquad \text{and} \qquad \mu_{Profit}^{INV} = \frac{\theta_0 + \theta_1 + \theta_2}{1 - \gamma_1 - \gamma_2}$$

Appendix B: Description of the Data

All the data for the U.S. firms are drawn from the 1995 Standard & Poor edition of Compustat (the active and research files for Annual Industrial and Full Coverage firms were merged using both the current 1976-1995 files and the historical 1957-1976 files). Firms that are incorporated in a foreign country and wholly-owned subsidiaries were deleted. All firms are publicly-traded on U.S. stock markets. For more details see HALL [1990].

Except for R&D, the data for French firms are drawn from the SUSE datafiles of INSEE, which give the balance sheets and income accounts of all firms with more than 20 employees in all industries since 1978. These are collected from the fiscal statements of the firms concerned (BIC) and their answers to the firm annual surveys (EAE). Most of the firms are not publicly-traded. The data on R&D comes from the annual surveys on firm R&D expenditures performed by the Ministry of Research, which have been matched with the SUSE files over the period 1974-1993. This allowed us to distinguish between "R&D" and "non R&D" firms, and for the former to know the history of their R&D investment (with possibly zero amounts in some years). The quality of the distinction between the two types of firms and of our measure of R&D thus depends on the coverage of the annual surveys and accuracy of the reported R&D numbers; both seems fairly good.

Our samples are balanced samples restricted to the Manufacturing firms which were present for the whole period 1979-1993 and for which all the necessary information on the variables of our analysis was available in all fifteen years, after some preliminary cleaning of outliers. Basically we have trimmed our key ratio variables (I/K, K/S, Δs, CF/K and OPINC/K), so that one percent of the observations in the tails of each of them were removed.

The firm variables we use in our analysis are defined in the following way:

- S is the total sales (or turnover) deflated by production price indices at a comparable two-digit level in the two countries (expressed in 1985 millions of dollars or French francs: M$ or MF).
- E is the average number of employees during the year in thousands for US and at the end of the year for France.

- I is the investment in fixed assets deflated by an overall price index for investment P^I in Manufacturing industries (expressed in 1985 millions of dollars or French francs: M$ or MF). P^I is the price index from the national accounts.
- RD is the Research and Development (R&D) expenditures deflated by an overall price index for R&D P^{RD} in Manufacturing industries (expressed in 1985 millions of dollars or French francs: M$ or MF). P^{RD} is computed on the basis of of the overall decomposition of R&D expenditures in wages, materials and investment in equipment, and of the national accounts price indices for these three components.
- CF is the after-tax cash flow (Net profit plus depreciation allowances), deflated as sales (expressed in 1985 millions of dollars or French francs: M$ or MF). It is also equal to the operating income variable ($OPINC$), plus net financial profits, plus net extraordinary items, minus profit taxes.
- K is the net physical or "fixed" capital stock at the end of the year (expressed in 1985 millions of dollars or French francs: M$ or MF). It is computed by the so-called permanent inventory method with a constant rate of depreciation δ where $K_t = (1-\delta)K_{t-1}+I_t$. We have adopted an average value of 8% for δ and used as the benchmark value for the capital stock K_{t_0} in the first year the net book value of the firm fixed assets after some adjustment for historical inflation (based on an estimate of their average age).
- G is the net R&D or "knowledge" capital stock at the end of the year (expressed in 1985 millions of dollars or French francs: M$ or MF). Likewise K, it is computed by the permanent inventory method with a constant rate of depreciation δ' where $G_t = (1-\delta)RD_{t-1} + RD_t$. We have adopted an average value of 15% for δ' and constructed a benchmark value for the capital stock G_{t_0} in the first year (1979) using all the available presample history on firm R&D (possibly as far as 1958 for the U.S. but only 1974 for France).

Appendix C: Comparing Within and GMM Estimates

Tables 13 through 16 present the estimation results that we obtained separately for the investment and R&D equations (5) in the two countries, using the four following methods of estimation: total (pooled least squares), within (pooled least squares including firm fixed effects), first differenced-GMM (first differenced equations instrumented by lagged levels), and system-GMM (first differenced GMM supplemented by the level equations instrumented by one lagged first differences). All four types of estimation are performed including year dummies and the total estimates also include industry dummies at the 2-digit level. The instruments used for GMM on the first differenced equations are the log capital stock, log sales, and cashflow rate, all lagged 2 through 4 years (except for the U.S. investment equation where they are only lagged 3 and 4 years). For the system GMM, the level equations are instrumented by the first differences of log capital, log sales, and the cashflow-capital stock ratio, all lagged one year (and lagged 2 years in the case of U.S. investment).

The validity of the instruments is accepted in the case of the two GMM estimators, both by the Sargan test of overidentifying restrictions and the appropriate Lagrange Multiplier test (for serial correlation of order 2), with the only exception of the system GMM for U.S. investment. Note, however, that the validity of the additional orthogonality conditions implied by the system GMM (assuming that of the orthogonality conditions of the first differenced GMM) is accepted by the "differenced-Sargan tests" only for R&D in France. However, it appears that for both GMM estimators the standard errors on the estimated coefficients, and especially the long run sales and cash flow parameters, are very large, and that the system GMM is not much of an improvement in that respect over the first diferenced GMM. It also appears that irrespective of their large standard errors, the magnitude of many of these estimated coefficients is quite implausible. All this suggests the prevalence of the "weak instruments problem", and explains why we chose in this paper to focus on the within estimates, which are both more precise and more plausible (and which in fact, taking into account the large standard errors of the GMM estimates, are not in general statistically different from them).

Table 13. Comparing Methods of Estimation for France - Investment

FRANCE - INVESTMENT : Dependent Variable : I_t/K_{t-1}

	TOTAL		**WITHIN**		**GMM-DIF**		**GMM-SYS**	
I_{t-1}/K_{t-2}	0.273	(.021)	0.052	(.021)	-0.048	(.101)	0.329	(.061)
Δs_t	0.173	(.015)	0.169	(.016)	0.068	(.108)	0.340	(.047)
Δs_{t-1}	0.076	(.012)	0.104	(.013)	0.096	(.093)	0.061	(.019)
$(k-s)_{t-2}$	-0.018	(.003)	-0.160	(.013)	-0.109	(.032)	-0.064	(.019)
s_{t-2}	0.000	(.001)	-0.048	(.008)	-0.044	(.074)	0.017	(.006)
Π_t	-0.057	(.018)	-0.063	(.017)	-0.146	(.086)	-0.013	(.074)
Π_{t-1}	0.072	(.018)	0.066	(.017)	0.115	(.059)	0.058	(.049)
Π_{t-2}	0.034	(.014)	0.031	(.014)	0.031	(.021)	-0.019	(.019)
Long Run Sales	1.020	(.051)	0.704	(.044)	0.594	(.722)	1.266	(.119)
Long-Run Cash-Flow	2.766	(.901)	0.206	(.109)	0.005	(.420)	0.390	(.522)
s and R^2	0.0759	0.2598	0.0713	0.3456				
LM Het. test	137.6	(.000)	363.7	(.000)				
DW Statistics	1.902	(.000)	1.869	(.000)				
Sargan test (p-value)					92.2	(.620)	161.2	(.069)
Dif. Sargan test (p-value)							69.0	(.002)
LM1 test (p-value)					-4.527	(.000)	-2.985	(.003)
LM2 test (p-value)					-0.586	(.558)	-0.130	(.897)

486 Firms, 5 832 Observations, Estimation Period : 1982-1993.
All four types of estimates are performed including Time Dummies. The total estimates also include Industry Dummies.
GMM First-Step Estimates.
Heteroskedastic-consistent standard errors in parentheses in the second column for each type of estimation.
Instruments for GMM-DIF: k from $t-2$ to $t-4$, s from $t-2$ to $t-4$, Π from $t-2$ to $t-4$,
Instruments for GMM-SYS: k from $t-2$ to $t-4$, s from $t-2$ to $t-4$, Π from $t-2$ to $t-4$ for differenced equations, Δk at $t-1$, Δs at $t-1$, $\Delta\Pi$ at $t-1$ for level equations.
Sargan test of Overidentification distributed under the null as χ^2 with 97 degrees of freedom for GMM-DIF, and 136 degrees of freedom for GMM-SYS, and Dif Sargan test as a χ^2 with 39 degrees of freedom.
LMj test for j-th serial autocorrelation in difference equation distributed as standard normal under the null.

Table 14. Comparing Methods of Estimation for the U.S. - Investment

U.S. - INVESTMENT : Dependent Variable : I_t/K_{t-1}

	TOTAL		**WITHIN**		**GMM-DIF**		**GMM-SYS**	
I_{t-1}/K_{t-2}	0.241	(.021)	-0.008	(.021)	-0.088	(.107)	0.436	(.070)
Δs_t	0.155	(.012)	0.152	(.012)	0.055	(.070)	0.136	(.046)
Δs_{t-1}	0.051	(.010)	0.071	(.010)	0.015	(.067)	0.048	(.038)
$(k-s)_{t-2}$	-0.011	(.003)	-0.158	(.011)	-0.091	(.061)	-0.038	(.011)
s_{t-2}	0.002	(.001)	-0.051	(.008)	-0.043	(.061)	0.001	(.005)
Π_t	0.019	(.016)	0.021	(.016)	0.064	(.133)	0.193	(.124)
Π_{t-1}	0.104	(.016)	0.127	(.015)	0.012	(.123)	0.099	(.125)
Π_{t-2}	0.005	(.016)	0.014	(.017)	0.049	(.070)	-0.133	(.061)
Long Run Sales	1.151	(.057)	0.678	(.037)	0.525	(.550)	1.029	(.129)
Long-Run Cash-Flow	11.602	(3.414)	1.030	(.170)	1.380	(2.769)	4.179	(2.060)
s and R^2	0.0772	0.3045	0.0713	0.4067				
LM Het. test	182.0	(.000)	407.7	(.000)				
DW Statistics	1.908	(.000)	1.883	(.000)				
Sargan test (p-value)					71.4	(.170)	162.9	(.000)
Dif. Sargan test (p-value)							91.5	(.000)
LM1 test (p-value)					-3.781	(.000)	-3.778	(.000)
LM2 test (p-value)					-2.055	(.040)	-2.807	(.005)

482 Firms, 5 784 Observations, Estimation Period : 1982-1993.
All four types of estimates are performed including Time Dummies. The total estimates also include Industry Dummies.
GMM First-Step Estimates.
Heteroskedastic-consistent standard errors in parentheses in the second column for each type of estimation.
Instruments for GMM-DIF: k from $t-3$ to $t-4$, s from $t-3$ to $t-4$, Π from $t-3$ to $t-4$,
Instruments for GMM-SYS: k from $t-3$ to $t-4$, s from $t-3$ to $t-4$, Π from $t-3$ to $t-4$ for differenced equations, Δk at $t-2$, Δs at $t-2$, $\Delta \Pi$ at $t-2$ for level equations.
Sargan test of Overidentification distributed under the null as χ^2 with 61 degrees of freedom for GMM-DIF, and 97 degrees of freedom for GMM-SYS, and Dif Sargan test as a χ^2 with 36 degrees of freedom.
LMj test for j-th serial autocorrelation in difference equation distributed as standard normal under the null.

Table 15. Comparing Methods of Estimation for France - R&D

FRANCE - R&D : Dependent Variable : R_t/G_{t-1}

	TOTAL		**WITHIN**		**GMM-DIF**		**GMM-SYS**	
R_{t-1}/G_{t-2}	0.551	(.033)	0.239	(.035)	-0.046	(.126)	0.520	(.070)
Δs_t	0.064	(.018)	0.075	(.017)	0.134	(.075)	0.069	(.060)
Δs_{t-1}	0.042	(.016)	0.072	(.017)	0.079	(.080)	0.060	(.024)
$(g-s)_{t-2}$	-0.008	(.002)	-0.140	(.015)	-0.219	(.062)	-0.031	(.017)
s_{t-2}	-0.004	(.001)	-0.048	(.015)	-0.124	(.058)	-0.009	(.009)
Π_t	-0.011	(.033)	-0.043	(.030)	0.009	(.095)	-0.009	(.098)
Π_{t-1}	0.067	(.038)	0.052	(.033)	-0.044	(.080)	0.007	(.081)
Π_{t-2}	0.022	(.031)	-0.001	(.030)	-0.002	(.032)	0.022	(.027)
Long Run Sales	0.402	(.232)	0.654	(.085)	0.432	(.289)	0.700	(.346)
Long-Run Cash-Flow	10.288	(4.985)	0.053	(.248)	-0.170	(.448)	0.655	(1.849)
s and R^2	0.0710	0.5924	0.0633	0.6765				
LM Het. test	198.6	(.000)	198.2	(.000)				
DW Statistics	1.658	(.000)	1.651	(.000)				
Sargan test (p-value)					100.7	(.378)	121.3	(.813)
Dif. Sargan test (p-value)							20.6	(.993)
LM1 test (p-value)					-2.821	(.005)	-1.124	(.261)
LM2 test (p-value)					-1.224	(.221)	-1.153	(.249)

214 Firms, 2 028 Observations, Estimation Period : 1982-1993.
All four types of estimates are performed including Time Dummies. The total estimates also include Industry Dummies.
GMM First-Step Estimates.
Heteroskedastic-consistent standard errors in parentheses in the second column for each type of estimation.
Instruments for GMM-DIF: g from $t-2$ to $t-4$, s from $t-2$ to $t-4$, Π from $t-2$ to $t-4$,
Instruments for GMM-SYS: g from $t-2$ to $t-4$, s from $t-2$ to $t-4$, Π from $t-2$ to $t-4$ for differenced equations, Δg at $t-1$, Δs at $t-1$, $\Delta\Pi$ at $t-1$ for level equations.
Sargan test of Overidentification distributed under the null as χ^2 with 97 degrees of freedom for GMM-DIF, and 136 degrees of freedom for GMM-SYS, and Dif Sargan test as a χ^2 with 39 degrees of freedom.
LMj test for j-th serial autocorrelation in difference equation distributed as standard normal under the null.

Table 16. Comparing Methods of Estimation for the U.S. - R&D

U.S. - R&D : Dependent Variable : R_t/G_{t-1}

	TOTAL		**WITHIN**		**GMM-DIF**		**GMM-SYS**	
R_{t-1}/G_{t-2}	0.631	(.029)	0.387	(.042)	0.344	(.118)	0.771	(.051)
Δs_t	0.110	(.013)	0.106	(.012)	0.024	(.042)	-0.041	(.038)
Δs_{t-1}	0.021	(.010)	0.047	(.012)	-0.031	(.040)	-0.004	(.017)
$(g-s)_{t-2}$	-0.013	(.002)	-0.094	(.011)	-0.075	(.034)	-0.007	(.013)
s_{t-2}	0.001	(.001)	-0.019	(.007)	-0.082	(.039)	-0.015	(.006)
Π_t	0.023	(.025)	0.016	(.027)	0.054	(.097)	0.279	(.086)
Π_{t-1}	0.089	(.021)	0.083	(.022)	-0.044	(.059)	-0.096	(.069)
Π_{t-2}	-0.030	(.017)	-0.054	(.019)	-0.064	(.034)	-0.095	(.030)
Long Run Sales	1.043	(.046)	0.802	(.078)	-0.090	(.548)	-1.130	(4.425)
Long-Run Cash-Flow	6.243	(1.996)	0.481	(.398)	-0.731	(1.487)	12.730	(25.192)
s and R^2	0.0612	0.5879	0.0575	0.6354				
LM Het. test	37.6	(.000)	76.1	(.000)				
DW Statistics	1.918	(.011)	1.874	(.000)				
Sargan test (p-value)					92.9	(.600)	155.6	(.120)
Dif. Sargan test (p-value)							62.7	(.009)
LM1 test (p-value)					-4.316	(.000)	-1.120	(.263)
LM2 test (p-value)					-0.947	(.344)	-0.871	(.384)

All four types of estimates are performed including Time Dummies. The total estimates also include Industry Dummies.
GMM First-Step Estimates.
Heteroskedastic-consistent standard errors in parentheses in the second column for each type of estimation.
336 Firms, 3 896 Observations, Estimation Period : 1982-1993.
Instruments for GMM-DIF: g from $t-2$ to $t-4$, s from $t-2$ to $t-4$, Π from $t-2$ to $t-4$,
Instruments for GMM-SYS: g from $t-2$ to $t-4$, s from $t-2$ to $t-4$, Π from $t-2$ to $t-4$ for differenced equations, Δg at $t-1$, Δs at $t-1$, $\Delta \Pi$ at $t-1$ for level equations.
Sargan test of Overidentification distributed under the null as χ^2 with 97 degrees of freedom for GMM-DIF, and 136 degrees of freedom for GMM-SYS, and Dif Sargan test as a χ^2 with 39 degrees of freedom.
LMj test for j-th serial autocorrelation in difference equation distributed as standard normal under the null.