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INVESTMENT UNDER LIQUIDITY CONSTRAINTS AND UNCERTAINTY: INVESTIGATING THE EFFECTS OF IRREVERSIBILITY

By

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Abstract

Irreversibility affects investment spending via two channels, a) financial constraints and b) uncertainty. According to our results, the impact of cash flow is accentuated for sectors facing higher irreversibility, implying that their investment spending is more sensitive to internal funds. In addition, the investment-uncertainty derivative is of larger magnitude for the group of sectors facing higher irreversibility. JEL Classifications: C23; E22; G31.
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1. Introduction

An extensive body of the literature on business fixed investment spending has focused on the effects of deviating from the Modigliani and Miller paradigm of perfect capital markets. These deviations, generated by informational asymmetries between lenders and borrowers, may lead to credit rationing where certain firms are denied access to credit altogether or, allowed to borrow provided they pay a substantial premium (Stiglitz and Weiss, 1981; Mayers and Majluf, 1984). A testable implication of this is that investment spending of financially constrained firms ought to exhibit excess sensitivity to cash flow or, in general, measures of internal liquidity. Numerous studies have provided evidence in favor of this hypothesis, by documenting that investment spending of firms classified as financially constrained (according to some observable attribute such as dividend payout, leverage, size, age) exhibits significantly higher dependence on internal funds (Fazzari *et. at,* 1988; Whited, 1992; Hubbard *et. al,* 1995; Vijverberg, 2004).

An equally extensive literature has focused on the impact of uncertainty on investment decisions that exhibit irreversibility. In a nutshell, it advocates that irreversibility creates a disincentive for investment by raising the trigger threshold after which investment becomes profitable (Abel and Eberly, 1999; Guiso and Parigi, 1999). Moreover, irreversibility and/or asymmetries of adjustment costs lead to a heterogeneous impact of favourable and adverse shocks, which makes optimal to 'buy' some insurance in the form of either less initial investment or deferring investment (McDonald and Siegel, 1986; Dixit and Pindyck, 1994).

Bridging these two seemingly unrelated investment literatures, Worthington (1995) proposes irreversibility as an alternative way of dichotomising decision makers between financially constrained and unconstrained. Consequently, the effect of irreversibility on investment manifests itself via two channels: a) the standard negative uncertainty effect arising from the irreversible nature of capital, and b) the amplification of cash flow dependence for financially constrained agents.

The present study makes a twofold contribution to the literature: a) employs a cross-sectionally and time varying conditional metric of uncertainty estimated by a Pooled Panel GARCH model (PP-GARCH, herafter) and b) considers the dual role of irreversibility on investment spending.

2. Literature Review

The neoclassical theory of investment developed by Jorgenson (1963) and Hall and Jorgenson (1967) advocates that a firm's optimization problem could be solved without reference to financial factors qualifying the user cost of capital as the sole determinant of investment. In a world without frictions (i.e. symmetric information, no taxes, no transaction costs and no other capital market imperfections) investment decisions would solely depend on whether the project at hand had a sufficiently positive net present value, and therefore could be financed by any combination of equity and/or debt capital. In contrast, the irrelevance hypothesis fails when the capital market is imperfect due to asymmetric information, taking the form of firm managers (borrowers) possessing superior information in comparison with investors (lenders). This asymmetry between lenders and borrowers generates an equilibrium characterised by credit rationing (Stiglitz and Weiss, 1981). Further research showed that without fully collateralized loans, the firm's balance sheet profile is used as a signal for its credit-worthiness, and in addition the perfect substitutability of external and internally generated funds breaks down (Greenwald, *et al,* 1984; Mayers and Majluf, 1984; Bernanke and Gertler, 1990; Gertler, 1992). Consequently, a cost differential, known as the External Finance Premium, exists between external and internal funds, with the former being more costly than the latter. This leads to the so-called Financial Hierarchy, which implies that firms wishing to fund their investment plans turn initially to own (internal) resources. External funds (borrowing or issuing shares) are not sought, until own resources are exhausted.

Another extensive literature has considered the non-uniform response of investment to uncertainty. Initially, Hartman (1972, 1976) and Abel (1983) advocated that uncertainty amplifies the incentive to invest. The positive response of investment to uncertainty arises from the convexity of the marginal revenue product of capital with respect to the uncertain variable and thus applying Jensen's inequality, a mean-preserving increase in the variance of the stochastic variable increases the optimal level of capital stock, and subsequently increases investment.

As frictions are introduced, the literature emphasizes irreversibility of capital leading to a marginal revenue product of capital being a concave function of the uncertainty variable (Abel and Eberly, 1994, 1999; Dixit and Pindyck, 1994; Eberly, 1997). Indeed, in the presence of fixed or sunk costs, firms may be reluctant to invest because of the possibility that they may wish to sell their installed capital in the future but will be able to reclaim little, if any, of the undepreciated value (Chirinko and Schaller, 2002). A similar conclusion has been reached by the Real Options Theory, which posits that in the presence of higher uncertainty, the firm may find it more prudent to postpone current investment until part of the uncertainty resolves. In other words, as the 'option' value of waiting increases, the opportunity cost of investment increases too, creating a negative effect of uncertainty on investment (McDonald and Siegel, 1986; Pindyck, 1988; Dixit and Pindyck, 1994; Abel *et al*, 1996; Caballero and Pindyck, 1996).

A careful look at the literature reveals that there are two distinct definitions of irreversibility. The first, which is technology-based, links irreversibility to the ability of the decision-maker to substitute between labour and capital. Hence, it relates to characteristics of the production technology suggesting that shocks may be absorbed by appropriately adjusting labour (Abel, 1983; Leahy and Whited, 1996; Lee and Shin, 2000). Thus, the adverse impact of a shock is inversely related to the degree of substitutability between labour and capital. A typical example is given by Leahy and Whited (1996) who compare firms in terms of the variance of their labour-capital ratio. They maintain that substitutability between the two production factors ought to be reflected on the variation of their ratio. Hence, they classify firms as facing higher irreversibility when their labour-capital ratio variance is below the sample median.

The second is transactions-based, and views irreversibility as a friction in the decision-maker's ability to undo capital commitments *per se* (Kessides, 1990; Worthington, 1995). In this context, the degree of irreversibility of investment decisions is inversely related to the 'depth' of second-hand markets for capital goods that impede resale or, inversely related to the activity of lease markets that allow users to commit for a fixed period of time without any cost of exiting. Kessides (1990) develops a transaction-based metric, pointing out that the share of sunk outlays ('sunkness') is likely to be low in industries using capital that can be easily leased, or using capital for which an active second-hand market exists. In other words, the intensities of the rental and resale markets in an industry could be viewed as proxies for the mobility and fungibility of the capital employed in the industry.

3. Data and Econometric Model

We use semi-aggregated firm balance sheets and profit and loss accounts for 10 manufacturing sectors[1], each sector is divided into 3 size classes, for *Austria, Belgium, Italy, France, Netherlands, Germany, Finland, Spain, Portugal, Sweden,* and *Denmark,* for the period 1987 to 2002 provided by the Bank for the Accounts of Companies Harmonised[2]. Thus the basic decision unit corresponds to a given sector from a given country and of given size class. We constructed the following variables

Investment; $\left(\frac{I}{K}\right)_{i,t}$, (Acquisitions of Tangible Fixed Assets - Sales and Disposals divided by the beginning-of-period capital stock, K),

growth rate of sales; $\Delta\log\left(\frac{S}{K}\right)_{i,t}$, ($\frac{S}{K}$: the ratio of Turnover to beginning-of-period capital stock),

cash flow; $\left(\frac{CF}{K}\right)_{i,t}$, (Gross Operating Profit over beginning-of-period capital stock), $ECM_{i,t-2} \equiv (k-y)_{i,t-2}$ (the difference of the logarithm of Total Assets and the logarithm of Turnover).

We classify a sector as facing more (less) irreversible investment when the variance of its labour-capital ratio is below (above) the median value, $Var\left(\frac{L}{K}\right)_t^{med}$, obtained from the distribution of all sectors for a given year (Leahy and Whited, 1996). Hence, the irreversibility dummy is defined as:

$$IRR_{s,t} = \begin{cases} 1, \text{ if } Var\left(\frac{L}{K}\right)_{s,t} < Var\left(\frac{L}{K}\right)_t^{med} \\ 0, \text{ if } Var\left(\frac{L}{K}\right)_{s,t} > Var\left(\frac{L}{K}\right)_t^{med} \end{cases} \tag{1}$$

We consider sector-specific uncertainty, $(\sigma_{i,t})$, proxied by the conditional volatility of Net Operating Profits, estimated by a Pooled Panel GARCH model (see Cermeno and Grier, 2005). The PP-GARCH model imposes common dynamics on the variance-covariance process across cross-sectional units reducing the number of parameters dramatically. Furthermore, the PP-GARCH model does not imply constant cross-sectional correlation over time.

An accelerator type model is employed, reflecting the information content of sales growth for future investment profitability (Abel and Blanchard, 1986), augmented by an error correction model underlying the presence of adjustment costs that may impede full adjustment of the actual capital stock to the desired level (Bond *et al.*, 2003), controlling for past investment behaviour and time effects. Error-correcting behaviour requires that the coefficient on the term $ECM_{i,t-2} \equiv (k-y)_{i,t-2}$ is negative, so when capital stock is above the desired level investment is reduced. Our empirical specification corresponds to the following model:

$$\left(\frac{I}{K}\right)_{i,t} = \delta_0 + \delta_{cf}\left(\frac{CF}{K}\right)_{i,t} + \delta_{unc}(\sigma)_{i,t} + \delta_1\left(\frac{I}{K}\right)_{i,t-1} + \delta_2\Delta\log\left(\frac{S}{K}\right)_{i,t} + \delta_3\Delta\log\left(\frac{S}{K}\right)_{i,t-1} +$$

$$\delta_4(ESM)_{i,t-2} + \sum_{t=1987}^{2002}\tau_t\,(time\ dummies) + \varepsilon_{i,t} \tag{2}$$

The parameters of equation 2 will be estimated separately for the constrained and unconstrained sectors. We *a priori* decompose decision makers between constrained and unconstrained based on the metric of irreversibility that has been generated according to their ability to substitute labour for capital. The parameters of interest are associated with cash flow and uncertainty, where we expect that the respective investment sensitivities will be higher for the group of constrained sectors. In other words, higher irreversibility renders exiting from previous commitments, in the form of owing capital, relatively more difficult, which intensifies the severity of capital market imperfections. In addition, higher irreversibility deepens the adverse effect of unanticipated shocks by raising the threshold that triggers investment, due to increased option value of waiting.

4. Empirical Results

The parameters of equation (2) are estimated by the Arellano and Bond (1991) GMM dynamic panel technique and estimation results are reported below.

TABLE

Estimation Results

	Low Irreversibility	**High Irreversibility**
Regressor	**Estimates (z-scores)**	
$\left(\frac{CF}{K}\right)_{i,t}$	**0.09*** (9.99)**	**0.13*** (8.80)**
$(\sigma)_{i,t}$	**-0.039 (-0.74)**	**-0.031*** (-4.26)**
$(ECM)_{i,t-2}$	-0.05*** (-7.65)	-0.02*** (-4.11)
$\left(\frac{I}{K}\right)_{i,t-1}$	0.51*** (39.96)	0.57*** (43.94)
$\Delta\log\left(\frac{S}{K}\right)_{i,t}$	0.09*** (20.93)	0.05*** (11.71)
$\Delta\log\left(\frac{S}{K}\right)_{i,t-1}$	0.003 (1.36)	-0.005** (-2.45)

continues

Time Dummies	Included	Included
Observations	1043	1041
Diagnostics		
m_1	-6.31***	-6.30***
m_2	1.65	-0.32
Sargan	110.11*	96.87

Notes: Numbers in parentheses denote z-scores, m_1 and m_2 are residual first and second order serial correlation tests, while Sargan stands for the over-identifying restrictions test. One, two, three asterisks denote significance at the 10, 5, and 1 percent level respectively.

The validity of the choice of instrumental variables is confirmed by the reported Sargan test statistics at 5% confidence level, while there is no sign of second-order autocorrelation. Columns (2) and (3) report separate estimates for the two subs-samples of low and high irreversible sectors. While the results of the two columns are qualitatively similar, the statistical significance is more pronounced for high irreversible sectors in column (3). In particular, a lagged dependent variable is included to allow for dynamic adjustment indicating the persistence of current investment behaviour on its past rate. In line with theory, the coefficient for the sales growth is highly significant with a positive sign confirming the accelerator effect. The speed-of-adjustment parameter is significantly negative for both groups, while its absolute magnitude suggests a very sluggish response to deviations from the frictionless capital stock.

In accordance with previous studies *(e.g.* Hoshi *et al,* 1991; Schaller, 1993; Vermeulen, 2002) cash flow carries a positive sign, which may also be compatible with its informational content regarding future profitability. However, cash flow coefficients are of different magnitude across the two sub-samples, a finding indicative of the presence of liquidity constraints. Thus, the impact of cash flow is accentuated for sectors facing higher irreversibility, implying that their investment spending is more sensitive to internal funds.

Uncertainty affects investment negatively, for both groups, a finding that is in line with previous empirical studies (Leahy and Whited, 1996; Guiso and Parigi, 1999; Goel and Ram, 2001). In addition, the investment-uncertainty derivative is more significant and, perhaps more importantly, of larger magnitude for the group of sectors facing higher irreversibility. In fact, for the lower irreversibility group the uncertainty impact is insignificant.

5. Conclusion

In the present study we constructed an empirical model that accounts for the two channels via which irreversibility affects investment spending; financial constraints and uncertainty. Sector-specific uncertainty is proxied by the conditional volatility of Net Operating Profits estimated by a Pooled Panel GARCH model. According to our results, the impact of cash flow is accentuated for sectors facing higher irreversibility, implying that their investment spending is more sensitive to internal funds. In addition, the investment-uncertainty derivative is of larger magnitude for the group of sectors facing higher irreversibility.

Notes

1. 211; Extraction of metalliferous ores and preliminary processing of metal, 212; Extraction of non-metalliferous ores and manufacture of non-metallic mineral products, 213; Chemicals and man-made fibres, 221; Manufacture of metal articles, Mechanical and instrument engineering, 222; Electrical and electronic equipment including office and computing equipment, 223; Manufacture of transport equipment, 231; Food, drink and tobacco, 232; Textiles, leather and clothing, 233; Timber and paper manufacture, printing, and 234; Other manufacturing industries not elsewhere specified.

2. There are 330 decision units, each sector includes 33 decision units (3 size classes from 11 countries), there are 10 sectors as defined above, and the time span is 16 years. This provides us with a total of 5280 (33*10*16) observations.

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