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Investment: Constraints on firms and links between institutions and growth

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Research Report

Background

This project, part of the ESRC World Economy and Finance programme, has used firm-level data to study the investment behaviour of firms in a number of developing countries, and has used aggregate country-level data to study the relationship between investment and economic growth, and the determinants of persistent differences across countries in aggregate investment levels.

The focus of the first part of the project, using data on individual firms, has been to understand the impacts of uncertainty and capital market imperfections on investment and financing decisions. The background is that business investment has been chronically low in many of the world's poorest countries. The economic literature on investment has highlighted two potentially important reasons: the deterrent effect of high levels of uncertainty, and the cost or difficulty of financing investment. A distinctive feature of our research is that we have used firm-level datasets for China, India, Brazil, Morocco and Ghana to estimate structural models, which allow us to simulate the effects of reducing the level of uncertainty faced by these firms, or reducing their cost of borrowing to finance investment.

The focus of the second part of the project, using aggregate country-level data, has been to understand the potential effects of higher aggregate investment in raising either per capita income levels or long run growth rates, and to identify characteristics of countries that are associated with persistently low levels of aggregate investment. The background was recent research findings by the principal applicant suggesting a potentially important effect of investment on long run growth rates; and the broader interest in the literature on economic growth and development in understanding the channels through which political and financial institutions influence economic performance. The project has extended this research on capital accumulation and growth, accounting for cross-section dependence in the country-level data; and assessed the importance of institutional differences and financial development in explaining differences across countries in investment levels, while accounting for a wide range of other potential explanatory variables, including

measures of natural resource endowments, political instability and macroeconomic volatility.

Objectives

The main objective of the project was to produce innovative empirical research in these two areas. On the micro side, we have achieved this by using simulated method of moments estimators to estimate fully parametric structural models describing firms' investment and financial decisions. While these methods have recently been used to study firm-level investment behaviour in advanced economies like the USA and the UK, our work is innovative in applying these methods to study investment behaviour in developing countries. On the macro side, we have achieved this in two ways. In our work on the relationship between investment and growth, we have used recently developed estimators that allow for cross-section dependence in heterogeneous panels. In our work on investment levels, we have used alternative model selection procedures (Bayesian Model Averaging and the automated PcGets program) to identify robust explanatory variables from a wide range of candidates.

Our stated aims were to provide credible answers to four questions that are important in the context of promoting faster economic growth in developing countries. We have made substantial progress on two of these: how much more could firms in poorer countries be expected to invest if they enjoyed more stable conditions? And which institutional environments promote high levels of investment? Our findings are described in detail in the two nominated outputs from the project, and summarised below. We have developed models and methods that address another of these questions - how much more could firms in poorer countries be expected to invest if they had better access to credit? - although our current empirical results are more preliminary than those in relation to the effects of reducing uncertainty. We have compiled a rich dataset on the nature of institutions that will allow us to address the fourth of these questions - which institutions encourage a strong relationship between additional investment and faster growth? - although our work to date has focused on explaining differences across countries in investment levels rather than heterogeneity in the relationship between investment and economic growth. As explained in section 6 of the report form, a job change for one of the co-applicants meant that we have had less time to work on this part of the project than we anticipated. This is reflected in the expenditure on the project.

Methods

As anticipated in the application, our empirical research on investment behaviour at the firm level has estimated fully parametric structural models. Our basic model is similar to that considered by Abel and Eberly (*Journal of Monetary Economics*, 1999), Cooper and Haltiwanger (*Review of Economic Studies*, 2006) and Bloom, Bond and Van Reenen (*Review of Economic Studies*, 2007). Firms produce output using capital and other inputs, which is sold in imperfectly competitive product markets. Uncertainty is introduced into

the model through a stochastic demand shift parameter. Capital is subject to costs of adjustment, while other inputs are assumed to be perfectly flexible.

In our work on the effects of uncertainty, we simplify by assuming that the firm faces no financing frictions, but allow for a rich specification of adjustment costs, including partial irreversibility, fixed adjustment costs, and quadratic adjustment costs. These models do not have closed form analytical solutions, but can be solved numerically using numerical stochastic dynamic programming methods (value function iteration or policy function iteration). The numerical solution can be used to generate simulated firm-level investment data by tracking the firm's optimal investment decisions in response to a sequence of draws from the distribution of demand shocks. Parameters of the model can then be estimated by finding values that match features of the simulated datasets to corresponding features of the empirical data on firms. Features such as the proportion of firms that report zero investment (inaction) or very high investment rates (investment spikes) are informative for characterising the forms of adjustment costs that are particularly important, and features such as the serial correlation in investment rates and the correlation between investment rates and sales growth are informative for estimating the magnitude of these adjustment costs. Formally we estimate parameters using a simulated method of moments estimator, implemented using a slow but robust simulated annealing algorithm. Details of the algorithms we use to generate the simulated investment data and to estimate the structural parameters of the model are provided in Appendices A and B of the nominated output from this part of the project (Bond, Söderbom and Wu, 2007a). These are implemented using Matlab.

Similar methods are used in our work on the effects of capital market imperfections. Here our current model simplifies by allowing only for quadratic adjustment costs, but introduces additional costs that make it more expensive for firms to finance investment by borrowing or by issuing new equity than by using internally generated funds. This introduces a 'pecking order' for different sources of finance, and allows for the possibility that some firms' investment spending will be constrained by a shortage of low cost internal funds. Features of the data such as the proportion of firms that use long term debt and the correlation between investment rates and cash flow are informative for estimating parameters that describe the cost of borrowing.

Also as anticipated in the application, our empirical research on the relationship between aggregate investment and economic growth has used annual time series data on investment and per capita income for a large panel of countries. The current draft uses data for 94 countries in the period 1960-2000. We use a range of different econometric approaches to assess the robustness of our results. For example, we estimate models using pooled annual data for the whole sample (imposing common slope coefficients for all countries) and separately for sub-samples of OECD and non-OECD countries; we estimate pooled models using data averaged over non-overlapping five year periods; and we allow for heterogeneity across countries in all coefficients using a variant of the mean group estimator proposed by Pesaran and Smith (*Journal of Econometrics*, 1995). As well as updating the data using the latest version of the Penn World Tables, the extensions to this research within this project have allowed for a form of cross-section dependence, using the multiplicative factor structure approach developed by Pesaran (*Econometrica*, 2006).

Finally we have compiled an extensive dataset on characteristics of political, financial and legal institutions in many developing countries. This data also covers a range of historical and geographical characteristics, and measures of natural resource endowments, political instability and macroeconomic volatility. Cross-section regression methods have been used to study the determinants of long run differences across countries in the shares of total investment or private sector investment in national income. The current draft uses data over the period 1960-2003 for a sample of 61 developing countries. A distinctive feature of this work is the use of recently developed model selection procedures, such as Bayesian Model Averaging and the automated PcGets program, to identify a subset of robust predictors of these investment shares from a wide range of candidate explanatory variables. The data and methods we use in this research are described further in the nominated output from this part of the project (Bond and Malik, 2007).

Results

The results of this research project are written up in five papers that we summarise briefly in this section. Two of these are the nominated outputs from the project; copies of the others are available at http://www.nuff.ox.ac.uk/users/bond.

Firm-level investment behaviour

Bond, Söderbom and Wu (2007a), "Uncertainty and capital accumulation: empirical evidence for African and Asian firms"

This paper uses data on manufacturing firms in China, India and Morocco that was collected as part of the World Bank Investment Climate Surveys or Firm Analysis and Competitiveness Surveys, and similar enterprise survey data on manufacturing firms in Ghana that was collected by the Centre for the Study of African Economies at Oxford University. We estimate separate models for firms with 10-75 and 76-1000 employees. Key features of these samples are substantial fractions of firms that report zero annual expenditure on investment in machinery and equipment (varying between 67% for smaller firms in India and 18% for larger firms in China); and high positive serial correlation in investment rates (generally in the range 0.3-0.6, with a somewhat lower level for smaller firms in Ghana), whether or not we exclude the observations with zero investment. The former suggests an important role for non-convex adjustment costs (partial irreversibility and/or fixed costs), while the latter suggests an important role for strictly convex (quadratic) adjustment costs.

In order to account for these patterns in the investment data, we find an important role for both non-convex and convex components in our estimated adjustment cost functions. This finding is consistent with related research using US data (notably Cooper and Haltiwanger, *Review of Economic Studies*, 2006, and Bloom, "The impact of uncertainty shocks: firm level estimation and a 9/11 simulation", mimeo, Stanford University, 2006).

Also in line with this previous research on firm-level investment, and with applications of fully parametric structural models in many other contexts, we find that there are some features of the empirical data that our structural model cannot fully account for. This may suggest that there is more heterogeneity in the behaviour of firms within each sample than structural models of this kind are currently able to accommodate.

Different forms of adjustment costs have very different implications for the relationship between uncertainty and investment behaviour. An advantage of estimating these structural models is that we can simulate the effects of different levels of uncertainty on firm-level investment. We consider the impact on both short run adjustment dynamics (how quickly do capital stocks adjust to new information about demand?) and on long run capital accumulation (do firms tend to operate with higher or lower capital stocks on average if they are more uncertain about future demand?).

Our results suggest that firms would respond more quickly to new information about demand if they faced a lower level of uncertainty. This is consistent with the effect of uncertainty on investment dynamics found by Bloom (2006, *op. cit*.) and Bloom, Bond and Van Reenen (*Review of Economic Studies*, 2007), and reflects the role of partial irreversibility and/or fixed costs in our estimated adjustment cost functions. Quantitatively, however, we find this effect of uncertainty on adjustment dynamics to be quite modest.

A more striking result is that our estimated models suggest a strong negative effect of uncertainty on capital stock levels. For example, our simulations indicate that permanently halving the level of uncertainty could raise average capital stock levels by around 10% for firms in Morocco, or by around 20% for firms in China (i.e. using the parameter values that we estimate for these respective samples). This suggests a potentially important relationship between uncertainty and long run capital accumulation.

Both the sign and the magnitude of this effect on capital stock levels reflect the importance of the quadratic cost component in our estimated adjustment cost functions. This relationship is considered in more detail in a second paper discussed below.

Bond, Söderbom and Wu (2007b), "Pursuing the wrong options? Adjustment costs and the relationship between uncertainty and capital accumulation"

The recent economic literature on uncertainty and investment has focused on the effects of irreversibility or other forms of non-convex adjustment costs. These models have interesting implications for short run investment dynamics, rationalising a 'region of inaction' in which firms may prefer to 'wait and see' rather than undertaking positive investment in response to good news about their demand or productivity. Investment behaviour becomes more cautious, in this sense, in environments where firms face a higher level of uncertainty. Yet as emphasised by Abel and Eberly (*Journal of Monetary Economics*, 1999), this does not necessarily imply a negative relationship between uncertainty and average capital stock levels. In the case of irreversibility, firms are more cautious about expanding their capital stocks in response to good news today because they anticipate the risk of being stuck with more capital than they would like to have

following bad demand or productivity shocks in the future. The net effect of uncertainty on expected capital stock levels is ambiguous, balancing the effects of some firms undertaking less investment following positive shocks and some firms being stuck with excess capital following negative shocks. Calculations of this net effect reported by Abel and Eberly (*op. cit*.) for a model with complete irreversibility suggest that it may be small in magnitude.

We simulate investment data for a discrete time version of the model analysed by Abel and Eberly, and we extend this model to allow for more general forms of adjustment costs. In the special case with complete irreversibility, we replicate their analytical results. In contrast, when we consider a model with quadratic adjustment costs only, we find there is a monotonic and potentially large negative impact of higher uncertainty on average capital stock levels. Intermediate results are found for specifications with partial irreversibility or fixed adjustment costs.

We provide some intuition for this result by analogy with the effect of quadratic adjustment costs on capital stock levels along steady state growth paths. If capital is subject to higher adjustment costs than other inputs, then forward-looking firms that anticipate needing to adjust capital stocks in the future have an incentive to substitute away from capital towards other, more flexible inputs. We show this formally for firms with quadratic adjustment costs that experience positive steady state growth in demand, implying positive desired investment. Uncertainty introduces another reason why forward-looking firms will anticipate a need to adjust capital stocks in the future, as demand or productivity fluctuates following the realisation of good or bad shocks. Firms subject to capital stock adjustment costs again have an incentive to substitute away from capital towards more flexible inputs. With strictly convex (i.e. increasing marginal) adjustment costs, this incentive increases with the level of uncertainty, implying a negative relationship between uncertainty and expected capital stock levels.

While the simulation results presented in this paper are purely illustrative, the potential importance of this effect is highlighted by our empirical findings using data for African and Asian firms, as discussed above.

Bond, Söderbom and Wu (2007c), "Investment and financial constraints: empirical evidence for firms in Brazil and China"

To investigate the effects of capital market imperfections on firms' investment and financial behaviour, we have developed a second structural model in which firms face higher costs if they borrow or issue equity to finance investment spending than if they use internally generated funds. We assume an increasing marginal cost of borrowing, mimicking the effect of lenders charging higher interest rates to more indebted firms, and a high fixed cost of issuing new equity. This generates a 'pecking order' or financing hierarchy, as proposed by Fazzari, Hubbard and Petersen (*Brookings Papers on Economic Activity*, 1988), in which firms prefer to use internal funds. If desired investment spending exceeds available internal funds, firms initially prefer to use debt as the cheapest source of external finance, but they may resort to issuing equity if their cost

of borrowing becomes too high. Firms that are reliant on these high cost external sources of finance will also choose lower investment levels compared to otherwise identical firms with more plentiful internal funds. This generates a relationship between investment and the availability of internal funds that is absent under 'perfect' capital markets (i.e. when debt (or new equity) provides a perfect substitute for internally generated funds). This is the sense in which investment spending may be 'financially constrained' in this type of model.

This paper describes the model and illustrates the investment and financial behaviour of firms in different cases. One important extension here is that firms are subject to a transitory cost shock as well as a persistent demand shock. These transitory cost shocks generate variation in the availability of internal funds without affecting desired investment levels. It is the combination of positive persistent demand shocks with negative transitory cost shocks that raises desired investment relative to the supply of internal funds, and pushes firms into using more expensive external sources of finance.

We also present preliminary empirical estimates of the key structural parameters of this model, using World Bank Investment Climate Survey data for larger firms in China and Brazil. This illustrates that we can identify the parameters describing the cost of borrowing and the variance of these permanent and transitory shocks by matching features of these datasets, such as the proportion of firms with positive (long term) debt, the average debt-assets ratio, and the correlation between investment and cash flow. These estimates suggest that firms face a sharply increasing cost of borrowing in both countries, implying that investment spending may indeed be affected by financing constraints. Our initial estimates suggest that around one third of the sample firms in China, and almost half the sample firms in Brazil, would increase their investment spending if they had additional internal funds. We should stress that these estimates are much more preliminary at this point that those discussed in our empirical paper on the effects of uncertainty.

Counterfactual simulations illustrate the effects of a lower cost of borrowing on investment and financial behaviour. A lower cost of borrowing here should be interpreted as a lower cost of debt finance *relative* to the opportunity cost of using internal funds, not as a reduction in interest rates and discount rates generally. As expected, a lower cost premium for debt induces more firms to borrow, and raises the average debt-assets ratio. Perhaps surprisingly, this does not necessarily increase average capital stock levels. While firms that are financially constrained tend to invest more when they face a lower cost of borrowing, firms that are not financially constrained tend to invest less. The reason is that firms can reduce the risk of being financially constrained in the future by accumulating additional capital in periods when they are not constrained, so that a higher capital stock acts like a form of precautionary saving. This incentive to invest for currently unconstrained firms is reduced when the cost of borrowing is reduced, and the cost of being financially constrained in the future is correspondingly lower.

This effect on capital accumulation is a consequence of capital being the only asset that firms can hold in the model. In a richer model, firms may prefer to hold liquid financial assets as a hedge against the risk of being financially constrained in the future, rather than accumulating additional capital. In that case it would be more likely that a lower cost premium for debt would also increase average capital stocks. Work in progress is

extending our current model to allow firms to hold a financial asset as well as real capital, which will allow us to explore this possibility empirically.

Aggregate investment and growth

Bond, Leblebicioglu and Schiantarelli (2007), "Capital accumulation and growth: a new look at the empirical evidence"

This is a revised draft of an earlier paper, using aggregate country-level data on income per capita and investment as a share of GDP to study the effects of higher investment shares on income levels and long run growth rates.

As outlined in the research proposal, we have extended the earlier research in two main respects. First, we considered allowing heterogeneous dynamic specifications for the time series models estimated for each country in the panel. We can construct a mean group estimate of the long run parameters of interest, relating a permanent increase in the investment share to steady state income levels or growth rates, without imposing a common dynamic specification for all countries. However we found that this extension made very little difference to our earlier results, allowing country-specific parameters but imposing a common dynamic specification.

Second, we allow for a form of cross-section dependence in the shocks affecting per capita incomes in different countries at the same point in time. This uses the multifactor error structure approach proposed by Pesaran (*Econometrica*, 2006). Compared to our earlier results that assumed cross-section independence, this extension has little effect on our main findings for the full sample of countries, or for the sub-sample of non-OECD countries. Allowing for cross-section dependence indicates weaker evidence of a long run effect of investment shares on growth rates if we rely solely on the sub-sample of OECD countries.

The revised draft of this paper also updates the data from Penn World Tables used in the earlier version, and adds further analysis of both the validity and the strength of the instrumental variables that we use to estimate our dynamic growth models. The main results of the earlier version remain intact: we find robust evidence that increases in investment as a share of GDP predict not only higher levels of income per capita, but also faster long run growth rates. The magnitude of the effect on growth rates is not trivial. For example, moving from the lower quartile (8.43%) of the sample distribution of investment shares to the median (14.04%) is predicted to raise long run growth rates by around 1 percentage point per annum.

Bond and Malik (2007), "Explaining cross-country variation in investment: the role of endowments, institutions and finance"

This paper presents our main findings on the characteristics of developing countries that explain long run differences in both total investment and private sector investment as a share of GDP. We initially consider 43 geographical, historical, institutional, economic and financial factors, using the Bayesian Model Averaging and PcGets approaches to model selection to identify a subset of more robust explanatory variables. These include a measure of the constraints on the executive level of government obtained from the Polity IV database, and a World Bank measure of the share of natural resource capital in national wealth. Less discretion for the executive is associated with higher investment shares, perhaps because this allows governments to commit not to engage in *ex post* opportunistic behaviour. Abundant natural resources are associated with lower investment shares, perhaps because these increase inequality or conflicts of interest, and tend to weaken political institutions. However we find a significant negative effect of resource endowments after controlling for constraints on the executive. A measure of losses in the transmission and distribution of electricity is also found to be important in our models for private sector investment. Defective electricity provision, which may proxy for poor infrastructure more generally, predicts lower private sector investment.

After controlling for these factors, we find little or no additional information in measures of political instability or macroeconomic volatility, which have been emphasised as important determinants of cross-country differences in investment levels in some earlier empirical studies. In general we do not find a strong relationship between indicators of financial development and these measures of investment. However we do find a positive effect of private sector credit as a share of GDP in explaining private sector investment shares within the sub-sample of countries that experienced relatively volatile inflation rates. This suggests that financial development may play an important role in cushioning the impact of macroeconomic volatility on private sector investment.

These results hint at the potential importance of a focus on strengthening political institutions and improving the quality of infrastructure provision if the objective is to raise private sector investment levels on a sustainable basis. These considerations may be particularly important in the context of resource rich developing countries.

Activities

Most of the effort on this project has gone into obtaining the empirical results summarised in the previous section. We have started to present this research at seminars and conferences during the last year. We intend to continue this dissemination activity over the next year.

Our main paper on the effects of uncertainty on firm-level investment (Bond, Söderbom and Wu, 2007a) has been presented at conferences at the CSAE, Oxford University (March 2007) and the National Graduate Institute for Policy Studies, Tokyo (September 2007), and at seminars at Fudan University, Xiamen University and the World Bank.

Our paper on cross-country differences in investment shares (Bond and Malik, 2007) has been presented at the World Bank's Annual Bank Conference on Development Economics (May 2007) and at an ESRC World Economy and Finance project workshop held at the London School of Economics (June 2007).

Our paper on capital accumulation and growth (Bond, Leblebicioglu and Schiantarelli, 2007) has been presented at seminars at Cambridge University, Gothenburg University, Oslo University, the World Bank and the Inter-American Development Bank, and in a keynote address at the African Econometrics Society's annual conference in Cape Town (July 2007).

Outputs

The revised paper on capital accumulation and growth (Bond, Leblebicioglu and Schiantarelli, 2007) has been submitted to the *Journal of Applied Econometrics*. The remaining papers from the project will be circulated as working papers and submitted to scientific journals after further extensions and revisions have been completed.

Impacts

As yet the research results have not been applied outside the project. This largely reflects the relatively preliminary nature of most of the empirical results at this stage. We will publicise our findings more extensively among non-academic users as we become more confident of their robustness. We believe that the findings from this project will be of considerable interest in strengthening the evidence-base for the formation of policies aimed at promoting economic growth and development by raising private sector investment levels. This evidence is expected to be of interest to agencies such as the World Bank, the United Nations Industrial Development Organisation, the UK Department for International Development and the Swedish Development Agency.

Future Research Priorities

We note two areas where the research undertaken in this project could usefully be extended. One priority is to incorporate forms of unobserved heterogeneity across firms into fully parametric structural models of investment behaviour in ways that are both convincing and tractable. We have already started work on an extension to our current model that will allow firms in the same sample to have different trend rates of demand growth, as well as drawing different demand shocks from a common distribution. A second priority is to use the country-level data that we have now collected to study differences across countries in the relationship between investment and long run growth rates. This will be undertaken both by considering additional interaction terms (based on country characteristics, such as resource endowments) in the context of the dynamic

growth models used in Bond, Leblebicioglu and Schiantarelli (2007), and by considering cross-section regression models to explain heterogeneity across countries in the long run parameters of these dynamic growth equations.

A broader implication of our results on the relationship between investment levels and the quality of political institutions and public sector infrastructure provision is to highlight the potential importance of research in the broad area of political economy into effective policies aimed at strengthening institutions or improving infrastructure provision.