

# Financing Constraints in the Inter Firm Diffusion of New Process Technologies

Alessandra Canepa<sup>1</sup>  
Paul Stoneman<sup>2</sup>

**ABSTRACT.** This paper explores why finance constraints may impact upon the inter firm diffusion of new technology, incorporates these arguments in a hazard rate formulation of a diffusion model and then estimates that model using data relating to the adoption of CNC machine tools in the UK. The results indicate that financial constraints can be a significant factor in the diffusion process.

**Key words:** technological diffusion, CNC, financial constraints

**JEL Classification:** O3

## 1. Introduction

Ed Mansfield stands with Zvi Griliches as a founding father of diffusion analysis in Economics. Even today, 40 years on, it is impossible to properly work in this field without referring back to Mansfield's path breaking work in the 1960s as published in Mansfield (1968). This body of work stresses that diffusion is a process driven, or at the least conditioned by, economic factors, a finding that over the years has been extended and elaborated upon but not refuted (see, for example, Hall, 2004). In one of his earliest diffusion papers, Mansfield (1963), the intra firm diffusion of new technology (in this case diesel engines) was modelled and certain firm level financial variables were included as potential determinants of the diffusion process. In

particular a measure of firm liquidity (the ratio of the firm's current assets to liabilities in the 2 years prior to when it began to dieselize) was found to have a positive and significant impact upon intra firm diffusion. Although this result suggests that financial factors (defined to encompass all issues relating to the funding of those capital expenditures that are a part of the technological diffusion process) may play a role in the diffusion process, later diffusion research has not tended to pick up on Mansfield's lead, and has instead somewhat ignored this line of enquiry (Stoneman, 2001). This is despite the fact that within the literature upon investment in general (Hubbard, 1998) and even R&D (Hall, 2002) there has been a growing emphasis upon the importance of financial factors and constraints. In this paper we partially correct that omission by exploring the impact of financial constraints upon the inter (rather than intra) firm diffusion of a new process technology. We initially discuss the rationale for expecting finance constraints to have an impact and then incorporate these arguments in a reasonably standard hazard rate formulation of a diffusion model and estimate that model using data relating to the adoption of CNC machine tools in the UK.

In the following Section we discuss the nature of financial constraints and the reasons why they might exist and in Section 3 the existing empirical evidence relating to their existence and patterns. In Section 4 a diffusion model that can test for the existence of such constraints in the inter firm diffusion process is proposed and we discuss the data and estimation methods to be employed in that testing. The results are presented and discussed in Section 5 and conclusions offered in Section 6.

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<sup>1</sup>University of York  
Department of Economics and Department of Mathematics  
Heslington, York YO10 5DD  
United Kingdom  
E-mail: ac48@york.ac.uk

<sup>2</sup>Warwick Business School, University of Warwick  
Coventry CV4 7AL  
United Kingdom  
E-mail: paul.stoneman@warwick.ac.uk

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## 2. What are financial constraints and why might they exist?

According to Hall (2002) a financial constraint is said to exist when, even if there are no externalities involved in the firm's investment activity, there is a wedge (perhaps even a large wedge) between the rate of return required by an entrepreneur investing his own funds and that required by external investors. Stiglitz and Weiss (1981) consider a firm to be credit rationed if it does not get as much credit as it wants although it is willing to meet the conditions set by the lender on equivalent credit contracts. In essence therefore a firm is credit or financially constrained if it cannot raise external funding at the market price or in order to raise external funding it has to pay over the market price.

There are many reasons postulated as to why such financial constraints might exist. These are reviewed in Canepa and Stoneman (2003) as well as in Hall (2002). The existence of uncertainty and thus risk is a *sine qua non* of such constraints. Beyond this, the most commonly argued reasons for such constraints are asymmetric information between borrower and lender and moral hazard resulting from the separation of ownership and control, although capital market incompleteness and inefficiency, taxes, subsidies, bankruptcy costs, and the problems of measuring risk may also have roles to play. The literature argues that the importance and relevance of such financial constraints may differ across firm sizes, industries and countries.

Smaller firms may be relatively more tightly constrained because (i) the availability of internally generated funds may be more limited for smaller firms than larger firms (ii) problems of information asymmetries for small firms may also be more severe (iii) smaller, newer firms may have no track record upon which to base a case for funding and/or there may be fewer realisable assets to use as collateral and (iv) the costs (to funding providers) of search may mean also that the supply of finance to smaller firms is more severely limited.

Differences across industries may also exist so that, for example, firms in high-tech and newer industries may face stricter constraints to raising external (and internal) funding either in terms of

cost and/or availability. This is because: (i) in riskier industries it may be more difficult to raise funding from outside the firm purely because of the risk factor; (ii) in more high-tech sectors not only may risk itself be a factor but also the proportion of assets that are realisable may be lower; (iii) in high-tech industries innovation is more likely to be of a sort that has not been undertaken before elsewhere and it may be particularly difficult to observe the systematic risk of such projects (Goodacre and Tonks, 1985) and thus difficult to determine the appropriate discount rate to use in evaluating investments in the firm; and (iv) information asymmetries may also be greater in such industries.

Differences in national systems of innovation (see Nelson, 1993) across countries may lead to differing financial constraints upon firms operating in different economies (as the result, for example, of differing taxes and subsidy regimes, the completeness of markets for finance, the legal environment as regards bankruptcy, government intervention etc.). Of particular interest are differences in the financial environments in different countries (Mayer, 1990). Financial environments are both heterogeneous and changing. On the one hand, there are bank-based systems as typified by the German system and on the other, market-based systems as typified by the UK or US system. Most continental European systems are largely bank-based although there are signs of some movement in certain countries (e.g. France) from a bank-based to a market-based system. Alongside these different financial system environments there are different patterns of ownership of industry. The German system, for example, reflects greater private control, more concentrated ownership and more pyramid ownership. In the UK the pattern is for less concentrated holdings, less private control and few inter-corporate holdings. The financing of investment by firms also differs across systems. Although self-generated funds are the main finance sources for firms in all countries (except perhaps for SMEs) these are more important in the UK, for example, whereas bank finance is more important in bank-based systems.

It is argued that such differences across systems have important implications for the way firms behave. The argument is that bank-based