Can Institutional Change Impact High-Technology Firm Growth?: Evidence from Germany's Neuer Markt

David B. Audretsch** and Julie Ann Elston*

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*Contact author: Assistant Professor of Economics, Department of Economics, CBA, PO Box 161400, University of Central Florida, Orlando FL, 32816-1400, USA, Tel. (407) 823 2078, Fax. (407) 823 3269, Email: julie.elston@bus.ucf.edu. **Director of the Institute for Development Strategies and Ameritech Chair of Economic Development, Indiana University.

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Abstract

To facilitate the transformation of the German economy from the traditional manufacturing industries towards emerging new technologies, a new segment of the Frankfurt exchange was introduced in 1997 – *Der Neue Markt*. This study provides evidence that not only did many new firms obtain funding from the *Neuer Markt*, but that for the first time in recent history, Germany succeeded in enabling smaller firms to grow faster than larger firms. This suggests that the new policies were not only successful in promoting a new type of firm that otherwise might not exist, but in transforming the sources of growth and innovation *within* the German economy.

JEL Classification Codes: (O3, O4, L25)

Keywords: Innovation, Growth, Institutions, Germany

-- *A company like Microsoft would never have a chance in Germany*, Joschka Fischer, German Foreign Minister, in 1995[1]

1. Introduction

Ever since the post-world war II era, the rest of the world has associated Germany with remarkable economic prosperity and stability, providing both high employment and wages. The German model of a *social market economy* had generated a *Wohlstand*, or standard of living, that generated not only the material wealth found on the other side of the Atlantic, but also the high degree of social services and security found elsewhere on the European continent. This was reflected by an unemployment rate below one percent during the 1950s and 1960s, and which still remained at 0.5 percent as recently as 1970.

However, by the 1990s, this era of German prosperity with its assumed low rates of unemployment had clearly ended. By the middle of the 1990s, unemployment had reached double digits, reaching 11.4 percent in 1997 and 11.1 percent in 1998, which resulted from sluggish growth, leading policy makers to search for new policy solutions. The high-technology entrepreneurial sector in places such as Silicon Valley that had helped the U.S. to more than offset unprecedented corporate downsizing, had eluded Germany. While the American entrepreneurial revolution was fuelled by plentiful venture capital, angel capital and informal capital, the highly restrictive and traditional financial institutions seemingly pre-empted the possibility of developing high-technology startups in Germany.

[1] "Those German Banks and their Industrial Treasures," *The Economist*, 21 January, 1995, 75-76.

A policy response to German stagnation was to create a new institution capable of channeling investment funds into the development of small high growth technology firms – *Der Neue Markt*, which was founded in 1997.[2] The purpose of this paper is to examine whether the *Neuer Markt* succeeded in helping to create fundamentally different firms, constituting the core of a new German emerging technology sector which can be contrasted with the traditional manufacturing firms shaped by incumbent German institutions. We do this by comparing the growth patterns of firms listed on the *Neuer Markt* with those of listed manufacturing firms from 1970-1985. The results provide preliminary evidence that the *Neuer Markt* firms are, in fact, different. That is to say, that while older traditional firms exhibited a positive relationship between firm size and growth, smaller enterprises, or what has been called the German *Mittelstand*, grew more slowly.

The recent reorganization of *Neuer Markt* firms into "Premier" and "Domestic Standard" segments this year, while viewed by some as evidence of a failed experiment, acutally underscores the need to empirically examine what impact, if any, it had on high-technology firm creation and growth in Germany.

Results of this study provide a marked contrast with findings for the U.S. (Caves, 1998 and Sutton, 1997), where smaller firms have been found to exhibit systematically higher rates of growth than their larger counterparts both in the last few decades, as well as today. In fact he high growth provided by U.S. small enterprises has been so crucial as

[2] This study does not directly address issues relating to identification of the bubble topography of the *Neuer Markt.* And since our data and study end in 2001, we are unable to examine or generalize results beyond

an engine of U.S. employment growth, that the 2001 Economic Report of the President (p. 112) concludes that "Small firms have been responsible for much of the growth…More than 40 percent of all privately employed scientific researchers now work in these small firms."

This was particularly true for R&D intensive sectors. By contrast, this inverse relationship between size and growth is new for Germany. *Neuer Markt* firms exhibit a negative relationship between size and growth, meaning that smaller enterprises have the highest growth rates. This suggests that the *Neuer Markt* is helping not just to create a new type of firm that otherwise might not exist, but also to transform the sources of innovation and growth in the German economy.[3]

2. The *Mittelstand* Paradox in Germany

German unification in 1989 accelerated the process of globalization by enabling countries to participate in the global economy which had previously been excluded. This globalization combined with the telecommunications revolution led to the demise in the traditional sources of German comparative advantage in -highly skilled manufacturing industries. Pressed to maintain competitiveness in these traditional industries, where economic activity can be easily transferred across geographic space to access lower production costs, the largest and most prominent German companies deployed two strategic responses.

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this time period.

The first was to offset greater wage differentials between Germany and low-cost locations by increasing productivity through the substitution of technology and capital for labor. The second was to locate new plants and establishments outside of Germany. What both strategic responses had in common was that the German flagship companies downsized the amount of employment in the domestic economy.[4] As Table 1 shows, between 1991 and 1995 manufacturing employment in German plants decreased by 1,307,000 while it increased in foreign subsidiaries by 189,000 (BMWi, 2000). In the chemical sector, the decrease of domestic employment was 80,000, while 14,000 jobs were added by German chemical companies in plants located outside of Germany. In electrical engineering employment in German plants decreased by 198,000. In automobiles employment in Germany decreased by 161,000, while 30,000 jobs were added outside of Germany. [5]

Table 1 here

[4] For example, Siemens increased the amount of employment outside Germany by 50 percent, from 108,000 in 1984/85 to 162,000 in 1994/95. Over the same time period it decreased the amount of employment in Germany by 12 percent, from 240,000 to 211,000.Volkswagen increased the amount of employment in foreign countries by 24 percent, from 78,000 in 1984 to 97,000 in 1994. Over the same time period, it decreased employment in Germany by 10 percent, from 156,000 to 141,000. Similarly, Hoechst increased the number of jobs outside of Germany by 9 percent, from 78,925 in 1984 to 92,333 in 1994. The number of Hoechst employees in Germany fell over that same period by 26 percent, from 99,015 to 73,338. And BASF increased employment in foreign countries by 34 percent, from 29,966 in 1984 to 40,297 in 1994. Domestic employment by BASF fell by 17 percent over that same time period, from 85,850 to 65,969 (Audretsch, 1999).

[5] The reaction of the German public was to accuse German firms of not fulfilling their social contract. .As one of the leading newspapers, *Die Zeit*, accused German industry, "When Profits Lead to Ruin – More Profits and More Unemployment: Where is the Social Responsibility of the Firms?", "Wenn der Profit zur Pleite fuehrt: Mehr Gewinne – und mehr Arbeitslose: Wo bleibt die soziale Verantwortung der Unternehmer?" *Die Zeit*, 2 February, 1996, p. 1.

During the post-war era, there were several institutional features of the German financial system that sharply contrasted to that practiced in the United States and the United Kingdom, both of which may have impacted the extent to which enterprises are able to obtain access to finance (Vitols, 1998; and Deeg, 1998). Companies in Germany typically relied almost exclusively upon banks for external finance. During the 1970s and 1980s, the debt-equity ratios of small- and medium-sized companies averaged 1 to 1, with 80 percent of the financing coming from internal sources (Audretsch and Elston, 1997). By contrast, in the U.S., the comparable debt-equity ratios for small firms during this period was around 1 to 4, showing a substantially greater reliance on equity financing.

A second important feature of the German banking institutions has been the close ties between banks and firms. Not only are German banks legally allowed to own equity, underwrite shares, extend loans and exercise proxy votes, but Fohlin (2000) shows how long-term relationships between banks and the enterprises they finance are historically more the rule and less the exception in Germany. These long-term relationships have resulted in financing practices protecting the status quo interests of the large incumbent firms and entire industries (Deeg, 2000). This has meant that while financing has been provided to small- and medium-sized enterprises, bank-based financing has been biased towards the status quo firms, industries and sectors.

In addition, alternative forms of finance, such as equity markets have been limited in Germany. Germany's equity markets remain both small and underdeveloped when compared to U.S. markets. For example, in 1989 only 501 out of 2,682 *Aktiengesellschaften* (AG), or stock-held firms, were publicly held. An important and

striking institutional feature of German corporate governance is that most stock held firms --around 80 percent in 1989-- were not listed on the public stock exchange (Audretsch and Elston, 2001). Without equity finance, these small German firms have been more dependent on banks for external funding than their U.S. counterparts.

These institutional features of Germany have resulted in a paradox with respect to the system of financing for the German *Mittelstand*. On the one hand, the development of a finely layered network of institutions, linking together financial institutions, governments, and private firms has resulted in a system of finance in Germany which has served as a model for providing funds to small- and medium-sized enterprises. Not only was the *Mittelstand* the backbone of the German economy -the underlying reason behind subsequent rise to economic power- but it also appeared to have a played a more important role in German economic development than in either the United States or the United Kingdom.

On the other hand, while the German *Mittelstand* was the basis for Germany's economic success, one aspect became notably lacking by the 1990s – the lack of small high-technology companies in the emerging industries such as software, biotechnology, and computers. In summary, while the German institutions of finance and corporate governance succeeded in generating a successful *Mittlestand* for the traditional manufacturing industries, they were unsuccessful in providing finance for firm startups in the new emerging technology sectors.

3. New Policies and Institutions: *Der Neue Markt*

As German policy makers in the 1990s searched for new sources of competitiveness and employment growth, they became aware of the role that the new technology sectors, such as biotechnology, software and information technologies, played in generating growth and restoring competitiveness in the U.S. (Federal Ministry of Economics and Technology (BMWi), 1999).[6] Why had the new technology sectors emerged in the U.S. but not in Germany? One reason identified by German policy making institutions was that financial and other institutions facilitated the startup of new innovative firms in the U.S., while the traditional German financial institutions posed significant barriers to the startup and growth of new firms in the emerging new technology sectors.[7]

In order to create a similar transition to the emerging high technology sectors, Germany introduced a new financial institution, with the goal of providing finance to high technology and high growth startups. This new financial institution which became known as the *Neuer Markt*, consists of high growth, high-technology firms listed as a separate part of the Frankfurt stock exchange.

The *Neuer Markt* was introduced by the Deutsche Boerse on March 10, 1997 and quickly grew from 2 to 343 firms. For an exchange that formerly listed about 600 firms, this represents nearly a 50% growth in listed firms. Since late 2000 various forces have

[6] In The Courage to Innovate, the Federal Ministry of Economics and Technology (BMWi), 1999 concludes that "new technologies create growth and jobs" (p. 6) and that the central pillar of the innovation promotion is the programme "Venture capital for small technology-based firms", because "The majority of new jobs are being created by small and medium-sized enterprises" (p. 18).

[7] For example, *Der Spiegel* (no. 5, 1994, pp. 82-83) observed that, "Global structural change has had an impact on the German economy that only a short time ago would have been unimaginable: Many of the products, such as automobiles, machinery, chemicals and steel are no longer competitive in global markets. And in the industries of the future, like biotechnology and electronics, the German companies are barely participating."

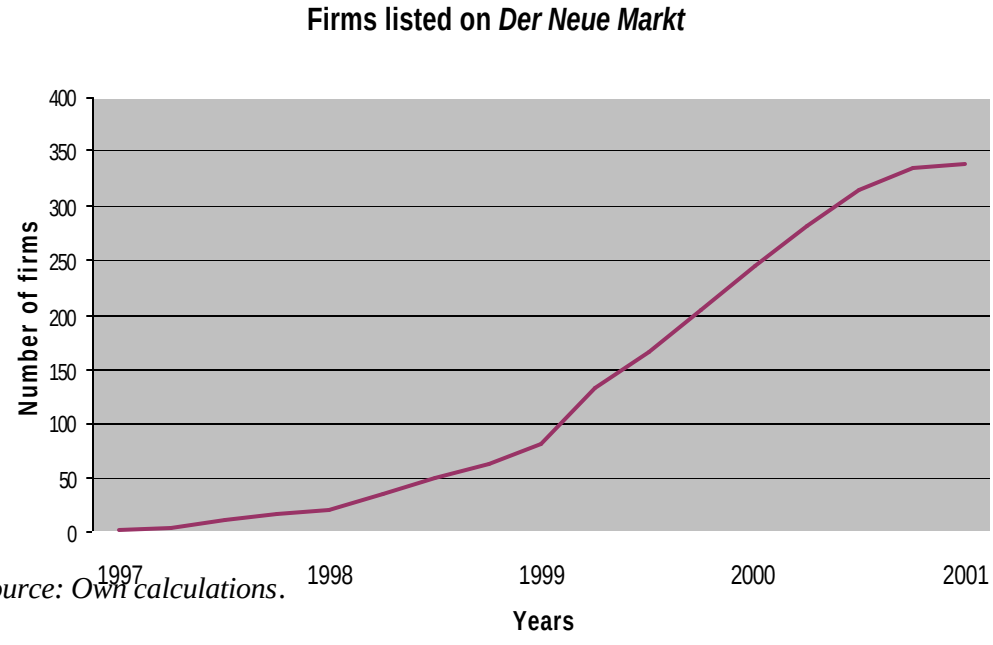
steadily inched the *Neuer Markt* downward leaving the index well below the opening value of 1000 points -far from the maximum value of 8559.32 points reached on March 10, 2000.[8] The reasons for the subsequent and potentially ongoing plunge of world equity markets, including the *Neuer Markt* are beyond the scope of this study, but provide potentially fertile ground for future studies.

Table 2 shows, the amount of capital raised on the *Neuer Markt* increased from 456 million € in 1997 to 13,689 million € in 2000.

Table 2 here

Similarly, Figure 1 shows that the number of firms listed on the *Neuer Markt* increased dramatically between 1997 and 2001.

Figure 1

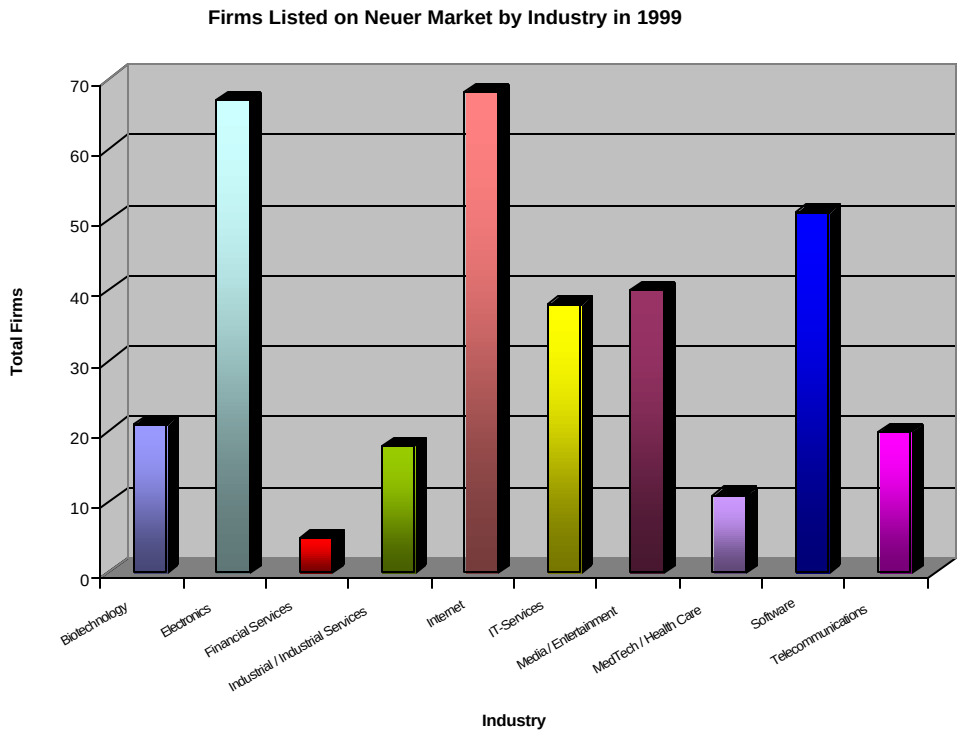


Source: Own calculations.

[8] During from March 2000 to July 2001 the market capitalization went from 234 to 58 billion euros.

A special feature of *Der Neue Markt* is the high concentration of startups in high technology sectors. These high-tech sectors include Biotechnology, Financial Services, Industrials & Industrial Services, Internet, Information Technologies, Media & Entertainment, Medical Services & Health Care, Software, and Telecommunications. In Figure 2 the distribution of firms across industries shows that the highest density of these firms were in the internet, electronic and software sectors.

Figure 2



In Figures 3 and 4 firm size and growth are displayed by industrial sectors. The firms with the highest grow rates between 1998 and 1999 were those in the internet, biotechnology and financial service sectors. In terms of size demographics, the largest firms occurred in the electronics, industrial, and It-service industrial sectors.

Figure 3

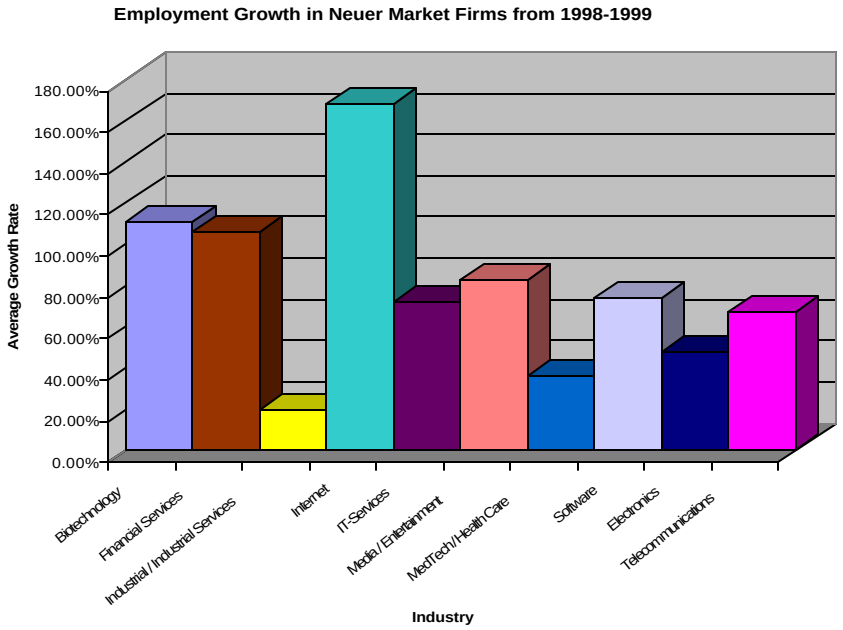
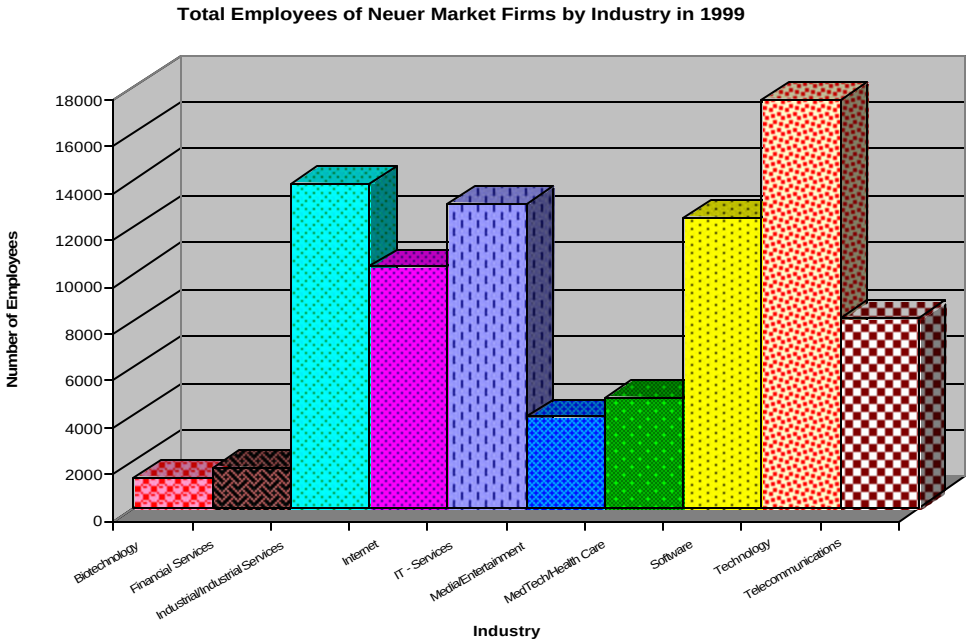


Figure 4



Admission and reporting requirements for *Neuer Markt* listed firms are more stringent than the rules for the first (*Amtlicher Handel*) and second (*Geregelter Markt*) segments of the Frankfurt exchange.[9] Firms are required to use the International Accounting Standards (IAS) or the US-GAAP reporting standards in addition to the *Handelsgesetzbuch* (HGB) or German Commercial Code. However some have made use of a short-term exemption period during which they may follow reporting requirements from the HGB only. In addition, they must report in English and German quarterly.

4. Has The Firm Size-Growth Relationship Changed?

A series of survey articles by Sutton (1997), Caves (1998) and Geroski (1995) summaries the findings from a plethora of empirical studies examining the relationship between firm size and growth. A *stylized result* (Geroski, 1995) emerging from this literature is that, when a broad spectrum of firm sizes is included in samples of U.S. enterprises, smaller firms exhibit systematically higher growth rates than their larger counterparts.[10] The growth advantage of small and new firms vis-à-vis large enterprises has been shown to be even greater in high technology industries (Audretsch, 1995). However, the links between firm size and growth and firm age and growth have been found to be much more ambiguous for Germany. While some studies have found no systematic relationship to exist between firm size and growth (Wagner, 1992) still other have actually found a positive relationship (Burgel, Fier, Licht and Murray, 2000). Only a

[9] Rules of the *Neuer Markt* are enforced by the *Bundesausichtsamt fuer den Wertpapierhandel* (BAWe) - the SEC equivalent.

[10] For example, Evans, 1987; Hall, 1987; Dunne, Roberts and Samuelson, 1988 and Audretsch (1995) find evidence of a negative relationship between firm size and growth for US firms.

few studies have found have results similar to the U.S. (Almus and Nerlinger, 2000; and Harhoff, Stahl and Woywode, 1998). Thus, the evidence that firm size was positively related to growth for Germany poses a stark and striking contrast to the U.S. economy.

As emphasized in Section 3, the *Neuer Markt* was created to promote the development of new emerging technology sectors led by high-growth small firms. One measure of success of the *Neuer Markt* therefore depends on its ability to generate new high-growth technology firms. To examine whether the *Neuer Markt* has achieved any success, we compare the relationship between firm size and growth for firms listed on the *Neuer Markt* and contrast the results with two benchmarks: (1) for German firms prior to the 1990s (to reflect the older traditional manufacturing sector) and (2) for the *stylized results* for the U.S. This provides us with useful benchmarks to compare whether the *Neuer Markt* has facilitated the development of a new breed of firms –which are smaller and younger technology based--than had previously existed in Germany.

Three comprehensive surveys (Sutton, 1997; Caves, 1998; and Geroski, 1995) identify that a common formulation of the relationship between firm size and growth, involves a decomposition of the present size of firm i in period into the product of a "proportional effect" and the initial firm size as:

$$\mathbf{Size}_{i,t} = (1 + e_t)\,\mathbf{Size}_{i,t-1}$$

where $(1 + \varepsilon_t)$ denotes the proportional effect for firm i in period t. Here the random shock ε_t is assumed to be identically and independently distributed. Taking the

natural log and using the fact that for small ε, $\ln(1+\varepsilon) \approx \varepsilon_t$, we derive the following relationship,

$$\mathbf{ln\ (Size_{i,t)} = ln(Size_{i,0)} + \sum_{k=1}^{t} e_{it}}$$

which as $t \to \infty$ results in a distribution which is approximately log normal with properties that $\ln(Size_{i,t)} \sim N(t\mu_\varepsilon, t\sigma^2_\varepsilon)$. [11]

Firm growth can then be measured as the difference between the log of the number of employees as:

$$\mathbf{Growth_{i,tn-t1} = ln(S_{i,tn}) - ln(S_{i,t1}) / (t_n - t_1)}$$

where the difference in Size for firm i between the current period t_n and the initial period t_1 equals Growth over that period.

Based on Hall (1987) and Evans (1987) the empirical growth equation for testing the hypothesis that initial firm size and impacts firm growth can then be specified:

$$\mathbf{Growth_{i,tn-t1} = B_1\ ln(Size_{i,t1)} + B_2\ ln(Size_{i,t1})^2 + B_3 Age_{i,t1} + e_{it}} \qquad (1)$$

where $growth_{i,tn-t1}$ for firm i in period $(t_n - t_1)$ is a function of size, $size^2$, age, and ε_{it} a stochastic error term. As Sutton (1997), Caves (1998) and Geroski (1995) report, the

[11] Almus and Nerlinger (2000) confirm this distributional assumption via kernal density estimates for German firms 1990-1996.

statistically consistent and compelling results emerging from estimating this equation are negative coefficients for the size and age effects.

The Role of Liquidity Constraints

One of the reasons why growth may vary across firm sizes is the result of differential access to finance. There are compelling reasons why liquidity constraints become more severe as firm size decreases. Stiglitz and Weiss (1981) pointed out that, unlike most markets, the market for credit is exceptional in that the price of the good -- the rate of interest -- is not necessarily at a level that equilibrates the market. They attribute this to the fact that interest rates influence not only demand for capital but also the risk inherent in different classes of borrowers. As the rate of interest rises, so does the riskiness of borrowers, leading suppliers of capital to rationally decide to limit the quantity of loans they make at any particular interest rate. In addition, the amount of information about an enterprise is generally not neutral with respect to size. Rather, as Petersen and Rajan (1992, p. 3) observe, "Small and young firms are most likely to face this kind of credit rationing. Most potential lenders have little information on the managerial capabilities or investment opportunities of such firms and are unlikely to be able to screen out poor credit risks or to have control over a borrower's investments."

If lenders are unable to identify the quality or risk associated with particular borrowers, Jaffe and Russell (1976) show that credit rationing will occur. This phenomenon is analogous to the lemons argument advanced by George Akerloff (1970). The existence of asymmetric information prevents the suppliers of capital from engaging

in price discrimination between riskier and less risky borrowers. But, as Diamond (1991) argues, the risk associated with any particular loan is also not neutral with respect to the duration of the relationship. This is because information about the underlying risk inherent in any particular customer is transmitted over time. With experience a lender will condition the risk associated with any class of customers by characteristics associated with the individual customer.

The purpose of including a measure of firm liquidity into the empirical model is two-fold. First, as explained above, by adding this measure we are able to examine the degree to which a firm's growth is impacted by liquidity constraints. A second interpretation, however, is that by holding liquidity constraints constant, we can focus on the relationship of interest –that of firm size to growth controlling for the liquidity constraints of the firm. We are able then to separate out the size effects into two factors, those which stem from financial size effect and those from other real size effects. This will allow us to distinguish then whether firm size may promote growth simply because larger firms have better access to capital or 2) whether other size effects related to firm life-cycle, economies of scale and scope, or other non-financial factors of importance.

Firm cash flows are used as a proxy of liquidity constraints of the firm in much the same way that they are introduced in empirical models in the investment literature.[12] The rationale for these models is that once we move away from the perfect capital

markets world, we find that both financial and real decisions matter to the firm. Liquidity problems, often exacerbated by asymmetry in information between suppliers of finance and firms for example, will influence real firm decisions such as investment in capital or labour –and by definition then, firm growth. We expect these problems to be particularly severe for smaller and younger firms with limited access to capital and little in the way of physical capital to use as collateral to secure debt.

An alternative model which controls for other factors related to growth including firm liquidity, variations in accounting year reporting, and industry effects can be specified as:

$$\mathbf{Growth}_{i,tn-t1} = \mathbf{B}_1 \ln(\mathbf{Size}_{i,t1}) + \mathbf{B}_2 \ln(\mathbf{Size}_{i,t1})^2 + \mathbf{B}_3 \ln(\mathbf{Age}_{i,t1}) + \mathbf{B}_4 \ln(\mathbf{CF}_{i,t1}) + \mathbf{B}_5 \mathbf{D}_{acctg} + \mathbf{B}_6 \mathbf{D}_{ind} + e_{it} \qquad (2)$$

where growth of firm i is a function of initial firm size, size^2, and age -- the number of years since the firm's IPO. CF, or cash flow, represents the proxy for the liquidity constraints of the firm, and ε a stochastic error term. We can also control for industry effects by using a vector of industry dummies D_{ind}, and a vector of interactive dummies which controls for both macro shocks and accounting year differences in annual reports D_{acctg}.

[12] For detailed description of the theoretical and empirical underpinnings of the liquidity constrained investment models see for example, Fazarri, Hubbard and Peterson (1988), Hoshi, Kashyap, and Scharfstein, (1991), Elston (1993), or Bond et. al (2003).

Dummies for accounting year scheme were constructed because some firms reported annual figures for a January-December accounting year while 70 firms had other accounting years including July-June. For firms with an end of calendar year accounting scheme one set of time dummies was created for each year, and for firms with any other than an end of year accounting another set of time dummies were created for each year. Regressions were run without an intercept term to account for the inclusion of these mutually exclusive dummies in the model.

Measurement Issues

The firm level data for the *Neuer Markt* firms comes from three sources -- the Hoppenstedt database, Deutsche Bundesbank data sources, and publicly available data from the web, which in total comprise 820 observations but not a balanced panel. The 341 *Neuer Markt* firms included in the database, along with their initial public offering (IPO) dates, and their industry groupings, are listed in Appendix A. The exact number of firms used in calculating summary statistics and regressions varied somewhat based on data availability for variables used in that year. Of the firms, 13% are not German, but originate from Austria, Britain, France, Israel, Ireland, Luxembourg, the Netherlands, Switzerland, and the US.

The data for the traditional manufacturing firms was taken from the *Bonner Stichprobe* (Bonn Data). This includes a sample of roughly all 295 listed manufacturing firms over the period 1970-1985. The Bonn Data was constructed from annual business

reports of firms, the *Handbuch Der Aktiengesellschaften*, and the *Statistisches Jahrbuch*. The Bonn Database consists solely of publicly listed firms in order to achieve comparability with the *Neuer Markt* firms, which by definition, are all publicly traded.

Sample selection issues can be a problem if the data sample consists only of the firm survivors. An examination of the *Neuer Markt* data reveals that up until May 2000 there were no firm deaths, and therefore there should be no bias in estimates due to entry and exit of firms during this sample period used in this analysis.[13] For the older traditional firms in the Bonn Data, 99 percent of the firms survived throughout the entire period, so again selection is not an issue.

The measure of firm size follows the most prevalent form in the plethora of studies linking size to growth reviewed by Sutton (1997), Caves (1998) and Geroski (1995), is the number of employees in the firm at the beginning of the sample period. Age is calculated for all firms in the sample. The oldest firm listed on the *Neuer Markt*, *PSIAG Gesellschaft* was incorporated in 1979, while the youngest firms in the *Neuer Markt* database are less than one year old. 281 firms were less than 2 years old, while there were 60 firms at least two years old.

The firm's cash flow was calculated by totaling the firm's cash, checks, and accounts at banks as reported on their balance sheet under the HGB accounting rules in

[13] According to the *Sueddeutsche Zeitung* Nr. 153, page 23, July 6, 2001, there were 6 firm insolvencies in the May-December 2000 time period including: Gigabell, Infomatic, Kabel New Media, Metabox, Micrologica, Refugium, Sunburst, and Teldafax. More were to come in the following years.

thousands of Euro.[14] Heteroscedastic consistent parameter estimates for regressions were obtained using White's (1980) approach, and are reported in the empirical results.

Table 4 reports descriptive statistics on firm size, growth, age, and cash flow in levels by industry groups and size for the *Neuer Markt* and *Traditional* economy firms. For *Neuer Markt* firms, most are very young -less than two years old. It is apparent that both mean industry growth rates and mean firm sizes vary widely. For example in terms of firm size, the Biotechnology (158), Internet (195), and Media and Advertising (161) sectors appear to be comprised of relatively smaller firms, with an order of magnitude smaller than Financial (1155) and Commercial Services (973). Table 5 presents a correlation matrix for key variables of the *Neuer Markt* firms. In particular, the correlations between firm size, firm size squared and age are quite high, which may indicate multicollinearity problems in estimating Equation 2.

Tables 4 and 5 here

Empirical Results

In Table 6 the results are presented comparing the estimation of firm growth between the traditional manufacturing and *Neuer Markt* firms. The growth rates are estimated for 1998-2000 for the *Neuer Markt* firms and 1970-1985 for the traditional manufacturing firms. In both sets of regressions the model is estimated using fixed effects. The fixed effects are for the industries represented in the traditional

[14] When data was reported in DM it was converted to Euro using the fixed exchange rate of 0.5102.

manufacturing firms, and for the technology sectors for the *Neuer Markt* firms. In addition, dummy variables are included for the year in both models.

Table 6 here

For the older traditional manufacturing firms, size is found to be positively related to firm growth. The negative coefficient of the quadratic term is more than offset by the magnitude of the positive coefficient on the linear term. Neither age nor the extent of liquidity constraints has a significant impact on firm growth. The positive relationship between firm size and age disappears for firms in high R&D industries. The classification according to R&D intensity is based on survey results reported in Beise and Licht (1996).[15] In addition, a positive relationship between firm age and growth is found for the high R&D industries. Thus, the results for the traditional firms in Germany provide a stark contrast with the benchmark results found for the U.S. (Sutton, 1997; Caves, 1998; and Geroski, 1995) that firm size and firm age are both negatively related to firm growth.

However, these results are considerably different for the *Neuer Markt* firms. In particular, firm size is found to have a negative and statistically significant relationship with growth. In addition, firm age is found to have a positive and statistically significant relationship with firm growth. The impact of age disappears once we control for cash flow.

[15] The survey revealed that chemicals (including pharmaceuticals), machinery, motor vehicles, electronics, and instruments, cameras, watches and clocks had the highest R&D intensities as well as the highest share of firms with R&D budgets and in-house R&D laboratories.

These results suggest that the *Neuer Markt* firms are considerably different than the firms from the older traditional manufacturing sample in that it is the smaller firms which exhibit higher growth rates. Unlike the traditional manufacturing firm sample, the *Neuer Markt* firms exhibit growth patterns more similar to the *Stylized Results* from the United States and other developed countries. While the larger firms exhibited higher growth rates for the traditional firms, the smaller enterprises exhibit systematically higher growth rates for the *Neuer Markt* firms.

Because of the high correlation among some of the explanatory variables for the *Neuer Markt* firms, which raises multicollinearity concerns, Table 7 examines several alternative model specifications. The negative and statistically significant impact of size on firm growth is found to be robust -- independent of model specification. Age is statistically significant only if cash flow is not included in the model. Including cash flow in the estimation renders the coefficient on age statistically insignificant. This may indicate that what previously has been inferred to be an impact of firm age on growth may, in fact, reflect the superior access of older firms to capital.

Tables 7 and 8 here

Table 8 provides further evidence of the robustness of the main results by estimating the model for three different sub-samples based on different criteria for what constitutes a small firm. Regardless of the partitioning criterion for size, the finding that

smaller firms grow faster remains robust. This suggests that the results are not dependent upon observations from a particular portion of the firm-size spectrum.

5. Summary and Conclusions

In an effort to facilitate the transformation of the German economy away from the traditional manufacturing industries and towards emerging technologies, a new institution was introduced in 1997 – *Der Neue Markt*. The purpose of the *Neuer Markt* was to generate what had previously eluded Germany – a new sector of small high-growth technology based firms in the emerging technologies. The results of this paper suggest that is something remarkably new about the firms made funded by the *Neuer Markt*. In the 1970's-1980's, older traditional large and mature firms had been the source of higher growth in Germany. This was particularly true in the R&D intensive industries. This new evidence suggests that the *Neuer Markt* has succeeded in generating a new generation of firms that are markedly different. This is evidenced by the reversal of the firm size-growth relationship, where the smaller enterprises exhibit higher growth rates.

There are a number of important qualifications to remember about the results from this paper. First, while we are able to show that the *Neuer Markt* firms exhibit a strikingly different pattern of growth than their older traditional industry counterparts, this does not mean that the emergence of small new technology based enterprises are found only among those firms listed on the *Neuer Markt*. The point of this paper is that the *Neuer Markt* provides at least one barometer of how institutional change is generating

an economic transformation in Germany. Whether such changes would have occurred in the absence of the *Neuer Markt* cannot be determined within the scope of this paper.

Second, it may be that such small high growth new technology firms existed but simply were not publicly listed and thus eluded the radar screen of our database. While unlikely, we cannot exclude such a possibility, as they would have had to have been sufficiently hidden to also evade notice of policy makers concerned with Germany's inability to transform its economy.

Third, the results of this paper provide no indication of the extent to which the type of entrepreneurial activity being created by Germany's *Neuer Markt* has influenced or spilled over to the rest of the economy. While this no doubt remains the major policy goal, at least one thing is clear from the results of this study – the *Neuer Markt* has succeeded in providing a new platform enabling Germany to achieve something that had previously been unattainable --the emergence of new high technology sectors driven by the small high growth companies listed on the *Neuer Markt*.

Finally, we note that while recently nearly a third of the *Neuer Markt* firms have either been voluntarily or non-voluntarily de-listed, the remaining firms are continuing on other segments of the Frankfurt exchange. This 30% "failure" rate, while not unusual for

firms in emerging technology sectors, has prompted concerns in Germany that new equity markets may not be the best solution for creating new firm growth and innovation.[16]

6. Policy Implications and Directions for Future Research

Germany needs to rethink its approach to financing the emerging technologies sector. The results of this study indicate that it may have been premature to consider dissolving this segment of the exchange –in effect throwing the baby out with the bathwater. This study raises several questions which may provide fruitful directions for future research.

First, it is of non-trivial importance to determine the causes of firm financial distress and death on the *Neuer Markt*. The reasons for the bursting of the (technology) stock market bubble world-wide also needs to be examined, as well as the bubble topology as this study describes only the early stages of the bubble. Some of the associated or contributing factors may include: Overvaluation of technology stocks, global recession or business cycle downturns, life-cycle or industry shakedown effects of inefficient firms in new emerging technologies sectors, misleading or fraudulent business/accounting practices, and life-cycle effects or immaturity (volatility) of the *Neuer Markt* itself. Industrial forensics on the causes of death are important because the implications for adapting successful future policy depends on the sources of the problems facing the firm. Inefficient and inappropriate technologies and technological applications will be forced

[16] The small but growing literature on small business innovation research does not necessarily consider de-listing a sign of firm failure. Firms may no longer be listed because they have merged, changed names, moved to other exchanges, etc. In addition, key personnel and technologies may have moved on to other

out of a well functioning market –especially during early industry shakedowns periods. Perhaps sustainable long-term growth will result from the inevitable economic recovery which will eventually lift all ships and allow the *Neuer Markt* to evolve to a more stable maturity.

Future studies should also explore what other mechanisms can be employed to assist the development of emerging technologies and start-up firms, including the potential role of government as venture capitalist.

Addressing these questions will be central to formulating the policies that will guide Germany out of its current economic stagnation and restore a high growth performance. Unless such policies promoting the transformation of Germany away from traditional manufacturing towards knowledge and technology based industries are considered, Germany will remain burdened by alarmingly high rates of unemployment and low growth. As this paper demonstrates, under the right set of policies and institutions, Germany is able to generate high-growth firms in the emerging technology and knowledge sectors.

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firms rendering the original firm insolvent, yet the innovation as a result of the initial funding was "successful" by some measure.

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Table 1
Change in employment figures in Germany and at foreign subsidiaries (1991-1995, in thousands)

Employment Sector	Manufacturing	Chemicals	Electrical Engineering	Automotive	Mechanical Engineering	Textiles	Banking and insurance
Foreign	**189**	**14**	**- 17**	**30**	**16**	**- 6**	**21**
Domestic	**- 1.307**	**- 80**	**- 198**	**- 161**	**- 217**	**-68**	**28**

Source: Bundesministerium fuer Wirtschafts und Technologie (German Federal Ministry of Economics and Technology, 2000).

Table 2
Market Capitalization of the *Neuer Markt*
(millions €)

Year	Capital raised
1997	456
1998	1,718
1999	7,589
2000	13,689
Total	23,452

Source: Deutsche Börse AG

Table 4

Panel A: Descriptive Statistics for Neuer Markt and Manufacturing Firms

	Industry / Size	Employees	Firm Growth	%Firm Growth	Cash Flow	Firm Age	Firms
1	**Biotechnology**	158.10	59.13	0.3740	24.73	16.33	21
		(240.41)	(76.1)	(0.32)	(38.99)	(13.80)	
2	**Financial Services**	1155.00	264.50	0.2290	1.35	20.75	5
		(1417.81)	(343.88)	(0.24)	(23.12)	(2.50)	
3	**Commercial Services**	973.11	364.43	0.3745	13.69	23.33	18
		(822.53)	(479.92)	(0.58)	(26.21)	(3.98)	
4	**Internet**	194.92	100.69	0.5166	30.05	12.00	68
		(367.67)	(153.77)	(0.42)	(65.79)	(9.68)	
5	**Software**	194.92	100.69	0.5166	30.05	16.00	51
		(367.67)	(153.77)	(0.42)	(65.790	(6.63)	
6	**Media and Advertising**	160.98	34.56	0.2147	22.79	8.00	40
		(314.67)	(64.82)	(0.21)	(48.10)	(3.4)	
7	**Healthcare**	619.08	63.40	0.1024	9.89	6.00	11
		(1232.98)	(157.04)	(0.13)	(12.11)	(2.8)	
8	**IT Services**	253.09	65.56	0.2590	25.59	15.33	38
		(273.48)	(211.33)	(0.77)	(43.32)	(6.84)	
9	**Electronics**	299.66	47.57	0.1588	16.65	8.31	67
		(361.27)	(85.85)	(0.24)	(36.07)	(4.19)	
10	**Telecommunications**	402.59	142.15	0.3531	62.00	6.60	20
		(480.07)	(330.57)	(0.69)	(69.13)	(2.47)	
	Large	871.88	282.92	0.3245	44.38	17.30	98
		(707.39)	(331)	(0.47)	(72.82)	(8.91)	
	Small	99.27	29.24	0.2946	20.60	9.31	241
		(76.64)	(78.73)	(1.03)	(50.05)	(5.85)	
	All Firms	313.66	100.64	0.3209	22.57	16.00	339
		(512)	(219.27)	(0.43)	(52.67)	(12.13)	
	Minimum	2.00	-957.00	-0.3037	96.00	1.00	
	Maxmum	3587.00	1679.00	5.1997	698916708.00	32.00	

Panel B: Manufacturing Firms 1970-1985

Industry	Employees	Firm Growth	%Firm Growth	Cash Flow	Firm Age	Firms
High R&D Intensive	17679.29	1116.40	0.0007	1064.07	122.19	72
	(35010.12)	(2370.44)	(0.0714)	(2901.06)	(48.07)	
Low R&D Intensive	3203.5	174.47	-0.0509	146.72	130.23	205
	(6650.89)	(907.58)	(0.1424)	(494.58)	(91.39)	
Total All Firms	6652.71	417.92	-0.0472	385.17	128.11	277
Minimum	12.00	-1616.93	-0.9989	-1153.08	15.00	
Maxmum	201000.00	12338.00	1701.0000	18885.26	691.00	

All data for means is in levels. Standard deviation is in parenthesis. Number of employees is only available for 304 observations, therefore firm Size also.

Small firms have less than 313 employees, Large have 313 or more. Age is measured from date of incorp.

Growth is measured as level differences in number of employees ($e_t - e_{t-1}$), % growth is growth divided by e_{t-1}.

Table 5: Correlations of Key Variables

	Growth	Sizet-1	Size2t-1	CF	Age
Growth	1.0000				
$Size_{t-1}$	-0.3361	1.0000			
	(0.0001)				
$Size^2_{t-1}$	-0.3219	0.9802	1.0000		
	(0.0001)	(0.0001)			
CF	0.0173	0.1282	0.1138	1.0000	
	(0.8073)	(0.0691)	(0.1067)		
Age	-0.0574	0.4414	0.4634	0.1840	1.0000
	(-0.3261)	(0.0001)	(0.0001)	(0.0038)	

All variables are in natural logs. Size is measured by number of employees, growth is measured by changes in size.

Table 6.
Manufacturing vs Neuer Markt Firm Growth in Germany

	Manufacturing						Neuer Markt	
	A		B		C		D	
	All Firms 1970-1984		Low R&D Intensity		High R&D Intensity		All Firms 1997-2000	
Size	0.0782*	0.1016*	0.0937*	0.1312*	0.0236**	0.2857	0.0173	-0.1583*
	(2.7)	(2.73)	(2.97)	(3.48)	(1.72)	(1.62)	(0.82)	(-3.36)
$Size^2$	-0.004*	-0.0063*	-.0059*	-0.0094*	-0.0113**	-0.0170	-.0067*	0.0157*
	(-2.31)	(-2.33)	(-2.62)	(-3.17)	(-1.65)	(-1.51)	(-2.67)	(2.44)
Age	0.0003	0.0002	-.0262	-0.0258	0.1578*	0.1627*	0.0146*	0.0053
	(0.02)	(0.01)	(-1.61)	(-1.60)	(2.56)	(2.60)	(2.39)	(0.75)
Rev	---	0.000	---	0.00005**	---	0.00002	---	-0.0037
	---	(1.00)	---	(1.79)	---	(0.63)	---	(-0.76)
Adj. R^2	0.1912	0.1950	0.2874	.3019	0.2072	0.2139	0.6432	0.7758
F	4.22	3.97	5.24	5.16	1.25	1.16	24.94	18.34
(prob.)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.2827)	(0.0034)	(0.0001)	(0.0001)
N	226	226	168	168	58	58	198	198

Growth is measured as annual percentage change in employment. Traditional manufacturing firm estimates from 300 firm sample 1970-1984.

Neuer Markt estimates from 1997-2000 for 198 firm sample. All regressions use industry and beginning year time dummies.

Numbers in parenthesis are t-values, *=5% and **=10% statistical significance.

Table 7:
OLS Fixed Effects Regressions of Firm Growth

Growth	S_{t-1}	S^2_{t-1}	Age	CF	adj R^2	F Value
1	-0.1972*	-	-	-	0.2700	9.41
	(-4.43)	-	-	-		(0.0001)
2	-0.1502	-0.0108	1.1435*	-	0.7734	71.15
	(-1.47)	(-0.89)	(24.1)	-		(0.0001)
3	-0.2048	0.0043	0.0354	0.0218*	0.8692	82.56
	(-1.44)	(0.27)	(0.26)	(8.71)		(0.0001)
4	-0.1673*	-	0.0387	0.0218*	0.8691	89.38
	(-4.82)	-	(0.29)	(8.77)		(0.0001)
5	-0.2384*	-	1.1333*	-	0.7723	76.31
	(-9.30)	-	(24.5)	-		(0.0001)
6	-0.1565*	-	-	0.2251*	0.8681	98.76
	(-5.05)	-	-	(28.5)		(0.0001)

Regression 1 is based on Gibrat (1931). Regression 2 is based on Hall (1987) & Evans (1987).

Because of mulitcollinearity in Regression 3,4 , parsimonious models are represented in regressions 5,6.

All regressions are corrected for heteroscedas ticity and control for industry and year effects.

t-statistic is reported in parenthesis and a * indicates statistical significance of coefficient at the 5% level.

Table 8:

OLS Fixed Effects Regressions of Size on Growth

Size Definitions 1. Small ≤133	S_{t-1}	CF	adj R^2	F Value
Large	-0.2443* (-4.94)	0.0121 (0.6134)	0.6981	17.5300 (0.0001)
Small	-0.4442* (-6.56)	0.0018** (1.730)	0.6438	11.4500 (0.0001)
2. Small ≤313				
Large	-0.3270* (-3.36)	-0.0082 (-0.42)	0.7223	8.4000 (0.0001)
Small	-0.2845* (-6.19)	0.0220* (27.40)	0.9060	91.9600 (0.0001)
3. Small ≤500				
Large	-0.4382* (-4.18)	-0.0093 (-0.52)	0.8943	12.3700 (0.0001)
Small	-0.2525* (-6.47)	0.0221* (27.94)	0.8923	93.7100 (0.0001)

For example, Regression 1 classifies a firm as small if it has the median size, 133, or less, and large if it has more than 133 employees. In regression 2 small is defined as less than or equal to the mean size of 313. And regression 3 uses the cut off point of 500 employees or less to define small.

All regressions are corrected for heteroscedasticity and control for industry and year effects.

t-statistic is reported in parenthesis and a * indicates statistical significance of coefficient at the 5% level.