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Start-up complexity and the thickness of regional input markets

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HIGHLIGHTS

- We investigate the impact of input market thickness on regional start-up activity.
- Regional determinants of high and low complexity start-ups differ substantially.
- Population, employment and investment density are conducive to start-ups in general.
- Complex start-ups are pushed by a high density of human capital and R&D.

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ABSTRACT

Start-ups in different industry groups are classified according to their average complexity. We find that thick regional input markets are conducive to start-up activity in general and complex start-ups in particular, but that some inputs are more important than others.

1. Introduction

Although there is a large literature on the determinants of regional variation in new firm formation (starting with Reynolds et al., 1994), locational needs of different kinds of start-ups have received relatively little attention. Most research has focused on start-up activity in general, neglecting that, for instance, locational needs of new services firms might differ fundamentally from those of new manufacturing firms or that high tech firms rely on other regional resources than low tech firms.

Only recently a theoretical link between regional input market thickness (IMT) and the complexity of feasible start-up projects has been proposed by scholars of urban economics (Helsley and Strange, 2011). On the basis of their theoretical findings it is possible to advance the following hypotheses:

H1: *regional IMT has a positive impact on regional start-up activity in general.*
H2: *highly complex start-ups depend more on regional IMT than low complexity start-ups.*

Our study assesses these hypotheses empirically.

2. Operationalization of start-up complexity and IMT

2.1. Start-up complexity

We exploit two unique and complementary data bases for Germany, namely the Mannheim Enterprise Panel (MEP) and the KfW/ZEW Start-up Panel (KfW/ZEW-SUP). MEP is based on the database of Creditreform, Germany's largest credit rating agency. It provides information about the number of start-ups in Germany by region and industry (Almus et al., 2000).[1]

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[1] It does, however, not include detailed information on the firms' founders and on firm characteristics.

Table 1
Indicators of start-up complexity across industries.
Source: ZEW Mannheim; own calculations.

Industries	Firm size (average employment)		Average number of founders	Share of firms with own R&D	Share of firms with market novelties	
	1st year	4th year			National	Internat.
Cutting-edge technology manufacturing	+		+	+		+
High-technology manufacturing	+	+	+	+		+
Technology-intensive services			+	+		+
Software supply and consultancy		+	+	+	+	+
Non-high-tech manufacturing	+			+		
Skill-intensive services	−	−	+			
Other business-oriented services		+				
Consumer-oriented services		−	−	−		−
Construction			−	−	−	−
Wholesale and retail trade	−	−	−			

+ Industry mean significantly ($\alpha = 0,05$) above mean of the whole sample.
− Industry mean significantly ($\alpha = 0,05$) below mean of the whole sample.

Table 2
Indicators of start-up complexity available from KfW/ZEW-SUP.
Source: Own compilation.

Measures applied	Indicative of
Average employment size in 1st year[a]	Size of start-up
Average employment in subsequent years	Development of firm size over time
Average number of founders	Heterogeneity of founders' human capital
Share of firms with own R&D	Pursuit of highly sophisticated activities
Share of firms with novelties to the national market	Innovative output (national)
Share of firms with novelties to international market	International aspirations/Innovation, international

[a] Note that the KfW/ZEW-SUP also provides information concerning the average investment volume by industry. We have, however, abstained from using investment volume as measure of start-up size as this measure is strongly biased towards manufacturing industries.

KfW/ZEW-SUP draws on the same parent population as MEP and each of its yearly panel waves contains data on about 6.000 start-ups from almost all industries, stratified by ten industries (Table 1, first column). Its large cross-sectional dimension allows sound investigations of the characteristics of newly founded firms across industries (Fryges et al., 2010: 124).

As defining and measuring start-up complexity is a novel and sophisticated task and as there exists no perfect single indicator of start-up complexity we apply a whole bundle of complexity indicators from the KfW/ZEW-SUP, listed in Table 2. The underlying idea is that start-ups are on average more complex the larger they are, the faster they grow, the more heterogeneous founders' human capital they require, the more sophisticated activities (R&D, in particular) they carry out, the more innovative their output and the larger their international reach/their international aspirations are.

Data availability from KfW/ZEW-SUP necessarily constrains the choice of complexity indicators, which, nonetheless, nicely fits the existing literature on organizational complexity (e.g. Damanpour, 1996). Applying these complexity measures to the ten industry groups of the KfW/ZEW-SUP, we find (i) there are significant deviations of industry averages from the average of the whole sample,[2] and (ii) for most industries there is little ambiguity, i.e. the various complexity indicators applied all point into the same direction (Table 1).[3]

Based on Table 1 we group start-ups in cutting-edge manufacturing, high-tech manufacturing, technology intensive services and software supply and consultancy together and classify them as *highly complex start-ups in a narrow sense.*

Non-high tech manufacturing (NHM) is clearly above average in terms of average employment size (1st year) and share of firms performing own R&D, and about average regarding the other indicators. Hence, for robustness checks, we add NHM to *highly complex start-ups in a narrow sense* and label this broader group *complex start-ups in a broader sense.*

Start-ups in consumer-oriented services, in wholesale and retail trade and in construction appear to be the ones with the lowest average start-up complexity, and are thus classified as *low-complexity start-ups.*[4]

2.2. Dimensions of IMT

The most common indicators of IMT are *population density* and *employment density* (Fu, 2007), and therefore both are considered in our estimates. Just focusing on such general measures might, however, be insufficient, as recent theories suggest it is in particular the density of highly-skilled employment that creates knowledge spillovers conducive to entrepreneurship (Audretsch and Keilbach, 2007). Hence, *human capital density* is considered as an additional explanatory variable. As formal qualification may be not too informative with respect to the knowledge-creating capacity we consider *R&D density* as further measure of IMT. Finally, to avoid biases from neglecting physical capital, our regressors include *investment density* (Table 3 defines all variables).

As the three general agglomeration measures (population, employment and investment density) are highly correlated, the econometric specifications include only one of them at a time.

3. Empirical model and results

Our regional-level dataset was compiled from various sources indicated in Table 3. The 97 German planning regions form the regional basis of analysis, encompassing start-ups of the years

[2] Sample 2008.
[3] The only exception being skill-intensive services (SIS).
[4] Our classification rests on the assumption that the relative complexity of start-ups across industries is stable over time, as data from KfW/ZEW-SUP are only available from 2005 onwards. Robustness checks for different start-up cohorts (2006, 2008, 2010) give no hints on changes of relative start-up complexity across industries over time.

Table 3
Definition of variables.

	Name	Definition	Data source
Dependent variables	Intensity of highly complex start-ups in a narrow sense	Highly complex start-ups (narrow definition) per 10.000 working-age inhabitants	MEP; KFW/ZEW-SUP
	Intensity of complex start-ups in a broader sense	Complex start-ups (broader definition) per 10.000 working-age inhabitants	MEP; KFW/ZEW-SUP
	Intensity of low complexity start-ups	Low complexity start-ups per 10.000 working-age inhabitants	MEP; KFW/ZEW-SUP
Measures of IMT	Population density	Number of inhabitants per km^2	DESTATIS[a]
	Employment density	Number of employees per km^2	FEA[b]; DESTATIS[a]
	Investment density	(Manufacturing) Investment per km^2 over 4-year-period	DESTATIS[a]
	Human capital density	Share of university graduates in total employment	FEA[b]
	R&D density	Share of R&D workers in total employment	FEA[b]
Control variables	Disposable income	Total disposable income in the region/population	DESTATIS[a]
	Unemployment rate	Registered unemployed as percentage of total labor force	FEA[b]
	Share of small enterprises	Employment share of firms < 20 employees	FEA[b]
	Manufacturing orientation	Employees in manufacturing/total population	DESTATIS[a]
	Export orientation	Share of export revenues in total manufacturing revenues	DESTATIS[a]

[a] German Federal Statistical Office.
[b] German Federal Employment Agency.

Table 4
Regional determinants of low and high complexity start-up intensity in German planning regions, 1998–2005. Estimation method: maximum-likelihood multi-level mixed effects linear regression.

	Panel 1—Low complexity start-ups						Panel 2—Highly complex start-ups					
	Coeff.	*z*-stat.	Coeff.	*z*-stat.	Coeff.	*z*-stat.	Coeff.	*z*-stat.	Coeff.	*z*-stat.	Coeff.	*z*-stat.
Human capital density	6.67	0.23	2.06	0.07	−0.61	−0.02	21.17***	3.13	20.65***	3.17	20.51***	3.04
R&D density	75.52	1.37	82.92	1.52	72.69	1.32	43.77***	3.47	45.37***	3.69	41.35***	3.27
Population density	0.01**	2.35	–	–	–	–	0.01***	2.97	–	–	–	–
Employment density	–	–	0.01***	2.84	–	–	–	–	0.01***	4.04	–	–
Investment density	–	–	–	–	0.01***	2.63	–	–	–	–	0.01**	2.38
Disposable income	−0.41	−0.29	−0.45	−0.33	−0.02	−0.02	0.37	1.26	0.31	1.11	0.52	1.86
Unemployment rate	−22.24	−1.58	−19.74	−1.41	−20.73	−1.48	−14.48***	−3.86	−14.29***	−3.92	−14.90***	−3.95
Export orientation	−4.05	−0.77	−4.10	−0.79	−5.73	−1.09	−0.66	−0.59	−0.70	−0.64	−0.97	−0.86
Manufacturing orientation	−61.96**	−2.57	−60.14**	−2.54	−68.44***	−2.90	1.88	0.37	2.51	0.51	−0.43	−0.09
Share of small enterprises	14.94	0.72	19.81	0.96	18.82	0.90	11.79***	2.68	13.34***	3.09	11.39**	2.55
Constant	35.7	1.23	34.10	1.35	26.53	1.17	−7.65	−1.4	−7.33	−1.4	−9.41	−1.75
Standard errors												
Planning region effect	4.63		4.52		4.61		0.91		0.87		0.91	
Time effect	5.79E−08		1.59E−08		1E−0.8		0.47		0.47		0.49	
Residual standard error	3.43		3.45		3.43		0.81		0.81		0.82	
Specification tests												
Wald test—pvalue	0.00		0.00		0.00		0.00		0.00		0.00	
Likelihood ratio test—pvalue	0.00		0.00		0.00		0.00		0.00		0.00	

Notes: the null of the Wald test is that all the coefficients are equal to zero. The null of the LR-test is that all random effects are zero.
* Significant at 5% level.
** Significant at 2.5% level.
*** Significant at 1% level.

1998–2001 and 2002–2005.[5] As regions differ in size, we analyze start-up intensity[6] rather than the absolute number of start-ups. Our model specification is illustrated in Table 3. Regarding control variables we build on previous relevant studies.[7]

We build on the two-way error component model:

$$Y_{it} = \alpha + X'_{it}\beta + \gamma_i + \delta_t + u_{it}$$

where γ_i and δ_t are region- and time-specific effects and u_{it} is a stochastic error term.

Panel 1 of Table 4 displays the main findings regarding *low-complexity start-ups*. Population, investment and employment density have a significant positive impact, whereas the more specific measures human capital density and R&D density have no significant impact. Elasticities of significant variables computed at mean values range around 0.04.

[5] Measures of IMT and control variables refer to 1997 and 2001, respectively. Investment density is an exemption, as it is measured as 4-years-average (periods 1995–1998 and 1998–2001).
[6] Start-ups per 10.000 working-age inhabitants.
[7] E.g. Reynolds et al. (1994), Armington and Acs (2002) and Audretsch et al. (2010).

The determinants of *highly complex start-ups* (Table 4, Panel 2) differ substantially from those of low complexity start-ups. While there appears to be little difference with respect to the impact of population/employment density and investment density (which have a positive but rather small impact on all kinds of start-ups investigated), human capital density and R&D density have strong positive impacts only on highly-complex start-ups.[8] Our findings suggest that regional human capital and R&D are important sources of knowledge spillovers conducive to complex new ventures, which is consistent with the Knowledge Spillover Theory of Entrepreneurship (see Ghio et al., 2014).

Considering complex start-ups in a broader definition does not change the principal results. Moreover, the baseline results are robust to changes in the estimation technique (e.g. using panel data econometrics), inclusion of further control variables, dropping outliers, considering Laender specific effects, and bootstrapping.[9]

Elasticities computed at mean values, do not vary much across different model specifications. For R&D intensity they are about 0.5, for human capital intensity about 0.3, for population and investment densities around 0.05, and for employment density around 0.07. Therefore, although general density variables affect low-complexity start-ups too, their impact is stronger for complex start-ups.

4. Conclusions

In sum, H1 and H2 are clearly supported by the data. However, underlying relationships might be more complicated than reflected by the current theoretical research. While general agglomeration economies (as measured by population, investment or employment density) appear to favor a broad range of start-ups, complex start-up projects have rather different locational requirements and benefit strongly from a high regional density of R&D and highly qualified employees. A main insight from this study is, therefore, that it is not so much agglomeration in general but rather the thickness of regional labor markets for highly-qualified people and R&D workers that matters for the feasibility of highly complex start-up projects.

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[8] We also find marked differences w.r.t. to the impact of the control variables. While manufacturing orientation – which has a negative impact on low complexity start-ups – has no impact on highly complex start-ups, we find a negative impact of unemployment and a positive impact of the share of small enterprises on highly complex start-ups.

[9] The results of the robustness checks as well as the descriptive statistics and the pairwise correlation matrix of the regressors are available from the authors upon request.