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JENA ECONOMIC RESEARCH PAPERS · # 2020-017

The JENA ECONOMIC RESEARCH PAPERS
is a publication of the Friedrich Schiller University Jena, Germany (www.jenecon.de).

Initial Conditions and Regional Performance in the Aftermath of Disruptive Shocks: The Case of East Germany after Socialism

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October 2020

Abstract

We investigate how initial conditions that existed in East Germany at the end of the socialist regime impact regional development during the turbulent shock transition to a market economic system. Our investigation spans a period of almost 30 years. Both the self-employment rate (an indication of the existence of a pre-socialist entrepreneurial tradition) and the share of the workforce with a tertiary degree have a strong positive effect on regional development. We conclude that knowledge and a tradition of entrepreneurship have long-run positive effects on development in regions that face disruptive shocks. Entrepreneurship and knowledge play a less important role for development across West German regions, where no significant shocks occurred.

JEL-classification: L26, R11, N93, N94

Keywords: Entrepreneurship, knowledge, economic development, history, transformation, East Germany

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1. Sources of growth in a transition context[1]

Theories about regional growth in market economies are based on a variety of factors. Among the main determinants of regional development considered in these approaches are: the capital stock and investment, knowledge, innovation and entrepreneurship, as well as regional characteristics like city size, population density, and the region's accessibility in terms of transportation costs (Martinelli, Moulaert and Novy 2013; Capello and Nijkamp 2019). A key problem in the empirical analysis of growth processes is to identify the causal impact of potential determinants of growth. Are the factors associated with growth in a market-based economy, such as capital investment causing growth, or just a symptom of previous growth?

This paper examines regional conditions that existed just before the introduction of a market-based economic system. Hence, we analyze a situation where there is no previous market-mediated growth that could affect potential determinants for subsequent growth. This allows us to estimate the causal effect of certain factors that arguably enhance growth. More specifically, we investigate regional growth in the fundamental shock transformation process of East Germany that was triggered by the sudden demise of the socialist regime and the subsequent unification with West Germany around the year 1990 (Sinn and Sinn 1992; Brezinski and Fritsch 1995). Our analysis focuses on the initial regional conditions at the end of the socialist period in the year 1989 as explanatory factors. A basic advantage of this approach is that initial conditions may determine subsequent development, but cannot be shaped by these developments. Hence, an explanation based on initial conditions can be more valid and reliable in terms of causality than traditional attempts of growth accounting that are based on a production function with inputs such as labor and physical capital during the period of analysis (Audretsch, Keilbach and Lehmann 2006; Mueller 2006). Moreover, given the fundamental changes that characterize a transition from a socialist planned economy to a market system, analyzing growth based on a production function is inappropriate because the input-output relationships are anything but stable.

[1] Financial support of the German Federal Ministry of Education and Research in the framework of joint research project *Modernisierungsblockaden in Wirtschaft und Wissenschaft der DDR* (Obstacles to Modernization in the Economy and Science of the GDR) (project number 01UJ1806DY) is gratefully acknowledged. We are indebted to Maria Kristalova, Udo Ludwig, Mirko Titze and Korneliusz Pylak for helpful comments on earlier versions of this paper.

Using a rich variety of data, we identify a particularly important role of remnants of an entrepreneurial tradition and the regional knowledge base at the end of the socialist period for employment and GDP growth. Hence, initial conditions have relatively strong effects on the development of regions in a post-socialist context. Our results suggest that entrepreneurship and knowledge make regions more resilient to disruptive changes of the economic framework conditions. Running a similar analysis for the regions of the well-established West German market economy reveals that entrepreneurship and knowledge play a considerably less important role when compared to the context of the turbulent transition experienced in East Germany. Altogether, the results indicate that entrepreneurship and knowledge are key factors for regional growth in environments marked by disruptive change.

The remainder of the paper is organized as follows. Section 2 provides information about the empirical background. In this section, we also provide an overview of differences in the performance of East German regions subsequent to the regime switch in terms of employment and per capita GDP. Section 3 discusses our analytical approach, and the possible effects of initial conditions on growth in a post-socialist context. Section 4 introduces data, Section 5 presents the results of the empirical analysis, and Section 6 offers a discussion of the results. The final section summarizes and draws implications for research and policy.

2. Empirical background: Regional development in East Germany

At the end of the WWII in 1945, Germany was divided into four zones, each governed by one of the allied powers. The Western Allies (France, United Kingdom and the US) occupied the Western part of the country, and soon began the process of rebuilding the Federal Republic of Germany (FRG, West Germany) into a modern market economic state. The Eastern part of the country was occupied by the Soviet Union. The Soviets installed a socialist centrally planned economy system dominated by state-owned enterprises. In 1949, the German Democratic Republic (GDR) was founded and absorbed into the Soviet bloc. As a result of the highly inefficient socialist centrally planned economy system, large parts of the GDR economy were characterized by technically very backward facilities and a decaying infrastructure. The consequence was low labor productivity, which, at the end of the 1980s, had achieved only just under 30% of the West German level (van Ark 1995).

The opening of East Germany's western border on November 9, 1989, was the first step of the country's shock transformation to a market economic system. All of a sudden, East German firms had to cope with competitors from the West. The introduction of the currency union with West Germany some months later on July 1, 1990, induced sharply rising wages and the loss of many customers from Eastern European countries that were now faced with much higher prices. Finally, the reunification of the two German states on October 3, 1990, led to a more or less complete transfer of the West German institutional system to East Germany that became effective virtually overnight (Sinn and Sinn 1992; Brezinski and Fritsch 1995).

This shock transformation required the instant and fundamental restructuring of East German society. It plunged the East German economy into a deep and long-lasting crisis that is still felt today. The value of production in 1991 fell to 35% of the value achieved in 1989. The number of people employed in eastern Germany declined from 7.8 million in 1989, to 5.8 million in 1993 (Figure 1).[2] Many firms had to sharply reduce employment or were forced to close. The result was skyrocketing unemployment rates.[3]

At the same time, many new businesses were set up (Fritsch, Kristalova and Wyrwich 2020). These newly emerging businesses, however, could not compensate for the employment losses. Despite a variety of political support programs that primarily involve the substantial transfer of funds from West to East, the economy in the former GDR has only incompletely recovered from these shocks. After nearly three decades of undergoing the transformation process, the economic performance measured by labor productivity amounts to not much more than about 80% of the West German level. Innovative activity is considerably weaker in the East, and the share of exports abroad is also lower than in western Germany (IWH 2019).

[2] Source: Statistische Ämter des Bundes und der Länder-Erwerbstätigenrechnung (2019).

[3] Official unemployment figures do not come close to fully reflecting the true level of employment problems. Not included in the official statistics are individuals who participated in public training programs, and those who were forced into early retirement. There was also a massive outmigration of former GDR citizens to West Germany instigated by economic conditions.

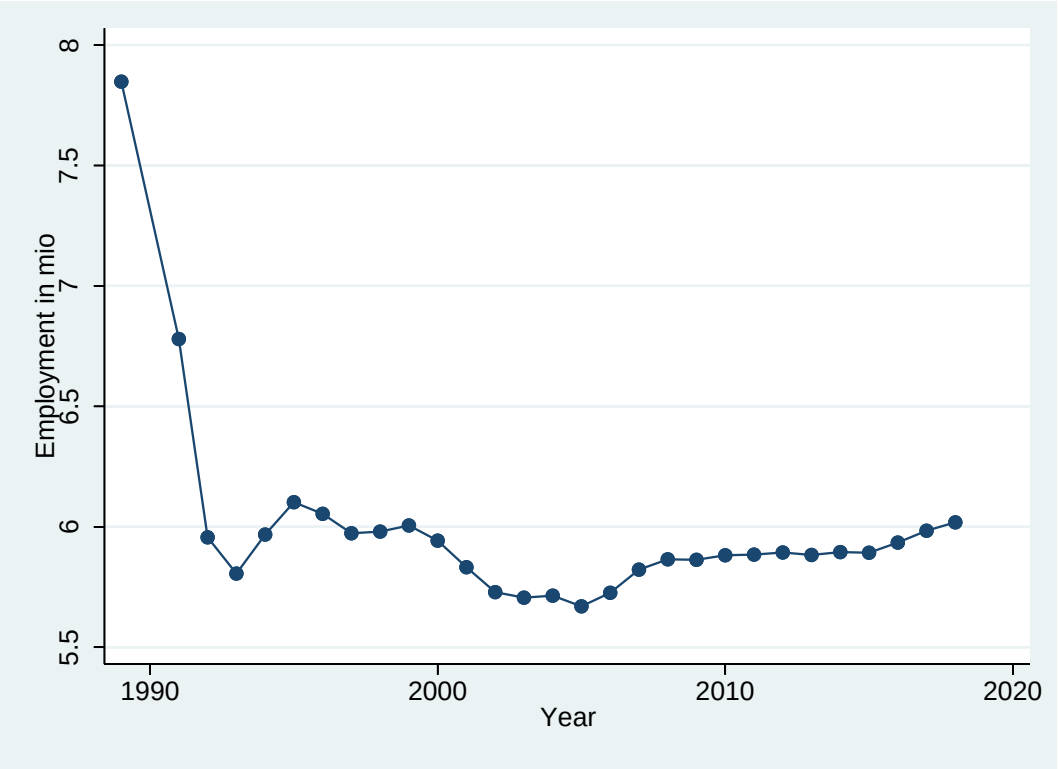

Figure 1: Employment development in East Germany (excluding Berlin) between 1989 and 2018.

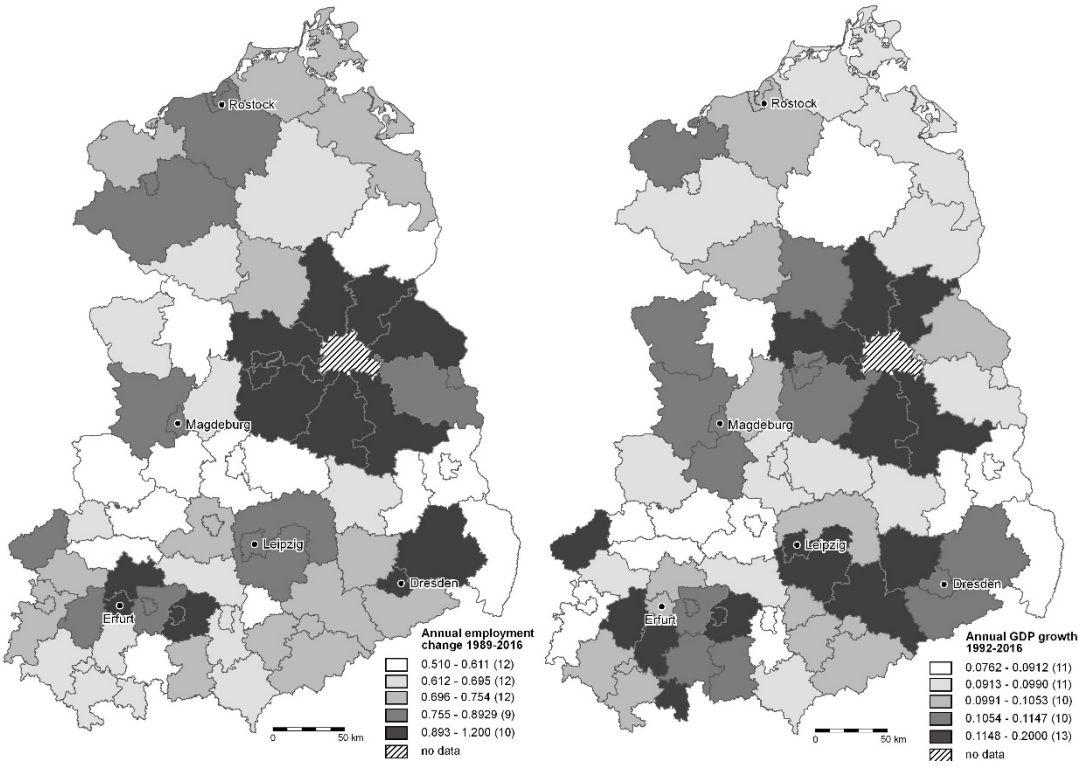

Figure 2: Annual employment change 1989-2016 (left) and annual GDP growth 1992-2016 (right) in East German regions

There are huge regional differences in these developments (Figure 2). While some East German regions such as Dresden, Jena and Leipzig show relatively strong growth, many other mostly rural areas (e.g., the areas south of Magdeburg, northeast of Dresden and in the North) fall far behind. Strong positive regional spillover effects can be found for the city of Berlin. It should be noted, however, that during East Germany's socialist era, Berlin was divided between the GDR and the FRG.[4] Some large investments made by Western firms after reunification tended to be concentrated in only a few industries that existed in well-established locations (e.g., automobiles and chemistry), and hardly created any new regional development trends (IWH 2019).

3. Analytical concept, theory, and hypotheses

3.1 Assessing regional growth in a post-socialist transition context

In the context of a fundamental transformation process, the standard approach of using a production function to assess regional growth (Audretsch, Lehmann and Keilbach 2006; Capello and Nijkamp 2019; Mueller 2006) has a number of disadvantages. One critical issue is identifying causal relationships if the regional output is regressed on current inputs. Did a certain input contribute to the output or was a longer-term development trend the reason for applying the input (hen-egg problem)? The identification of causal relationships is especially difficult in a turbulent transformation environment when an entire economy switches from central planning principles to a market-based system. Since firms, organizational procedures, the division of labor and applied technologies are subject to fundamental change, the input-output relationships in such a transition process are anything but stable.

Another problem with identifying causality when analyzing economic growth is that regions tend to follow long-term development trajectories (Fritsch and Wyrwich 2019). Empirical evidence suggests that important sources of growth may be deeply rooted in a region's history. These wellsprings of growth can be seen in

[4] Since Berlin was divided into four occupation zones, only the Soviet-occupied part, East Berlin, belonged to the GDR. The other three occupation zones in Berlin, West Berlin, were given a special status and were closely linked to the West German Federal Republic both economically and politically. Since German unification in 1990, there are no reliable separate statistics for the economic situation in East and West Berlin (which would not be meaningful given the extensive integration of both parts). For this reason, Berlin is excluded in the empirical analyses.

certain economic structures, a particular knowledge base, as well as informal institutions such as traditions and 'cultures' that shape the 'response' of actors to external challenges. Hence, if one should find a positive and statistically significant relationship between the investment into a region's physical capital stock and the growth rate, this may provide a rather limited 'explanation' if the investment decision is determined by historically grown regional conditions. In such a case, the question to be answered is: Why do actors in a certain region make a certain type of investment while actors in other regions behave differently?

A further problem is the availability and reliability of data at the regional level. For example, information on regional investment is often incomplete or unavailable, making any estimate of the regional capital stock uncertain. This is particularly true in countries and regions that are in a fundamental transformation process. Thus, it is hardly possible to meaningfully assess the value of the capital stock at the end of the socialist period, and then compute that value in the context of a market system. In an environment fraught with high levels of uncertainty and rapidly changing prices, investment decisions may follow other criteria than in well-established market economies found in West Germany or the US.

We attempt to explain the post-socialist development of regions by relating long-term regional development from the beginning of the transition process to regional factors that existed at the end of the socialist period. Hence, we assess the role of initial regional conditions at the advent of this disruptive historical shock for subsequent regional performance. Since we can rule out that the initial conditions were shaped by the subsequent transformation process, our approach allows us to identify causal relationships more reliably than the traditional production function method. Moreover, this approach avoids the problems of unreliable input data, especially the valuation of the capital stock that is particularly difficult in a transition context with high levels of turbulence, uncertainty and rapidly changing prices.

3.2 Determinants of regional growth in a post-socialist context

Joseph Schumpeter (1934) identified entrepreneurship as the main driver of growth. Schumpeter defines entrepreneurship as introducing something new or acting as an agent of change. It is plausible to assume that entrepreneurship is particularly important for economic performance in a transition context that is characterized by

rapid fundamental change and high levels of uncertainty. Hence, entrepreneurship may be a key resource that enables actors and regions to find a productive response to the enormous challenges of the transformation process and is conducive to a region's economic performance (see also McMillan and Woodruff 2002).

While quite a number of studies find a positive effect of entrepreneurship on regional growth in developed market economies (Fritsch 2013), this relationship has been left widely unexplored in a post-socialist transition context (see Berkowitz and De Jong 2005, as one of the few exceptions). In the socialist economies of Central and Eastern Europe there was hardly any self-employment because most private enterprises were absorbed by the state, and the few remaining private-sector activities that were tolerated were carefully controlled (for details, see Pickel 1992).[5] In East Germany, the share of self-employed people among the population aged 18 to 64 years was only 1.8% in 1989, compared to more than 10% in the western part of the country. There were, however, pronounced regional differences in the level of remaining self-employment that correspond to historical levels of self-employment before World War II. These regional differences in the share of people that resisted the massive anti-entrepreneurship policy by remaining self-employed may be regarded an indication of remnants of a regional tradition and culture of entrepreneurship that can be considered to be pre-socialist in origin (Fritsch and Wyrwich 2019).

A second general factor that should have a positive effect on economic performance is the regional knowledge base that is manifest in the qualification of the regional workforce, innovative activity, and specialization in certain technological fields or industries. A severe problem in measuring the regional knowledge base at the end of the socialist period is that a lot of knowledge depreciated over the course of transition since socialist countries followed different technological paths. Thus, patents as an indicator of the regional knowledge base at the end of the socialist regime can be problematic because the GDR, like other

[5] The socialist regime in East Germany favored collectivist values and declared entrepreneurship as a bourgeois anachronism (e.g., Pickel 1992; Thomas 1996). Hence, it implemented a rigorous anti-entrepreneurship policy strategy intended to eradicate entrepreneurship. The few private firms in existence at the end of the socialist period were primarily found in those small trades ill-served by inflexible centrally planned state firms. Remarkably, the remaining levels of self-employment were particularly high in those regions that had a pronounced entrepreneurial tradition in pre-socialist times (Fritsch and Wyrwich 2017).

socialist countries, followed different technological paths than those chosen in the Western world (see, e.g., Bentley 1992; Radosevic 1999; Stokes 2000). As a consequence, any indicator of the regional knowledge base at the end of the socialist era based on patents may not be adequate. Apart from that, the East German sector of education and research was radically reorganized in order to integrate it into the West German system. This reorganization was accompanied by a massive reduction in personal, financial and other resources. In the first years after transition, R&D employment decreased, on average, by 20% - 50% of what it was under socialism (Meske 2000). A more appropriate measure of the knowledge stock may, therefore, be the share of the workforce with a university degree. These are people who are likely to have a relatively high absorptive capacity to learn and recombine their human capital for productive use in a market economy. As human capital theory suggests (Becker 1962), the level of formal education indicates a higher general level of human capital and prosperity-enhancing productivity, not only at the individual level, but also at the regional level.

The role of agglomeration economies and diseconomies on regional development in a transition context is unclear. The transition processes experienced by the GDR involved significant urban adjustments and industrial relocation that may have limited any growth-enhancing features of agglomeration. Furthermore, the physical infrastructure of cities was in disrepair (e.g., Berentsen 1992; Andrusz et al. 1996). This situation was not conducive to the proper working of positive urbanization externalities and, by definition, market-mediated linkages that foster such externalities were absent in a centrally planned economy.

We do not expect that the effect of initial regional conditions remains stable throughout time. On the one hand, the effect may become less significant over time due to policy interventions and changes in growth-relevant regional conditions. Hence, the evolution of structural conditions that has occurred since the regime switch may become more and more important for regional growth. On the other hand, the impact of initial conditions may increase after the unobserved transition-specific influences caused by ‘transition noise’ during the first years of the regime switch may gradually fade away. This particularly includes the complex processes and effects related to the privatization of state-owned enterprises that could have shaped regional development in the first years of transition. Thus, regional initial conditions may reveal a stronger effect in later years of the transition process.

Our argument that the regional levels of self-employment and knowledge are of particular importance for coping with the challenges of a highly turbulent shock transformation process implies that these factors play a lesser role in the framework of a well-established market economy. Since the economic effect of German unification had hardly any effect on the West German economy that remained at its established growth trajectory, we can test this conjecture by running our models for both parts of the country (see Section 5.2). We expect that the effect of self-employment and knowledge in the West at the time for which we measure the initial conditions in the East are much less significant for explaining subsequent growth.

4. Data and definition of variables

The spatial framework of our analysis is based on counties. In our analysis, we also want to explore regional development in West Germany which was a fully-fledged market economy at the time of German reunification. Since some of the counties consist only of a city without the respective hinterland, we aggregate these regions with neighboring counties.[6] Based on this procedure, our data comprise 55 East German and 228 West German regions.

We use two dependent variables that describe regional development. The first measure is the annual employment change between September 1989 and the year 2016. Employment data for East Germany in 1989 are from the Statistical Office of the GDR as published in Rudolph (1990).[7] The employment data for West Germany in 1989 and all values for the years 1991 to 2016 are obtained from the working group on employments statistics (Statistische Ämter des Bundes und der Länder – Erwerbstätigenrechnung 2019). The second measure of regional performance is annual GDP growth as reported by the statistical offices (Statistische Ämter des Bundes und der Länder – Volkswirtschaftliche Gesamtrechnung 2019). We use GDP data from 1992 onwards, because this is the first year for which regional GDP figures for East and West German regions are available. While regional GDP per capita is a measure of regional wealth, employment is directly linked to the regional population's economic opportunities and does not necessarily imply high income.

[6] Berlin had to be excluded since parts of the city did not belong to the GDR and any separate statistics for the formerly socialist part of the city (that are unavailable) would not be meaningful.

[7] The employment data is not likely to have been falsified as was the case with the official productivity statistics (Kawka 2007).

Information on regional conditions in 1989 in West Germany are taken from the Federal Statistical Office and the Federal Employment Agency. Information on regional conditions across East German regions stem from the official employment and population figures of the GDR Statistical Offices as of September 30, 1989 (see Rudolph 1990, and Kawka 2007, for a detailed data description).[8] Hence, our data on regional conditions are taken from a point in time where transition-induced turbulence was not yet present. In fact, our data reflect a snapshot of conditions immediately before turmoil kicked in. For example, significant mass demonstrations that led to the fall of the Berlin Wall on November 9, 1989 began in early October. But even at that time, no one could reasonably expect German reunification and significantly changed framework conditions for start-up activity within 12 months.[9]

We include the following variables to account for the initial regional conditions in East Germany on September 30, 1989.

- The *self-employment rate* represents the regional tradition or 'culture' of entrepreneurship. It is measured as a ratio of the number of self-employed over the population aged between 18 and 64 years old.
- The *share of employees with a tertiary degree* represents the regional knowledge base. It is measured by the number of employees with a tertiary degree over total regional employment.
- *Agglomeration (dis-)economies* are measured by population density, which is the regional population divided by the area in square kilometers. This measure is included in order to control for diverse characteristics of the regional environment such as land prices, size of local markets, availability of inputs, etc. As previously noted, the role of agglomeration for regional growth in a post-socialist transformation environment is unclear (see section 3.1).
- The *share of employees in manufacturing* controls for the general economic structure at the end of socialist period.
- The *share of employees in large-scale manufacturing industries in total manufacturing employment* indicates the composition of the local manufacturing

[8] Since administrative borders of the regions have changed since 1989, we used information adjusted to current borders as in Kawka (2007), and based on own calculations.

[9] It is not possible to consider 1988 as a reference year because of a lack of data availability.

sector. We account for a possible large-scale effect by including the share of manufacturing employment in those industries, namely the chemical industry and the energy sector, that are characterized by high minimum efficient size in established market economies. Regions marked by such industries were supposed to be particularly vulnerable to economic decline after 1990 (Rudolph 1990).

In alternative specifications, we use regional patent activity in 1989 as a measure for the regional stock of knowledge. For East Germany, this data is obtained by regionalizing original patent files from the Patent Office of the GDR, while for West Germany this data come from the OECD regional patent database (RegPat). We calculate the number of patents per employee and use this measure in the analysis.[10]

As already mentioned (see Section 3.1), a valuation of the regional capital stock in East Germany at the end of the socialist period is meaningless. However, in order to control for post-unification capital inputs, we include measures for the *average investment among manufacturing firms in the year 1995*[11] and estimates for the *regional capital stock in 1996* in some of the models as a robustness check.[12] Since capital inputs may be an outcome of initial regional conditions (hen-egg problem), our preferred estimates are those without post-unification capital inputs.

In order to control for common characteristics across neighboring regions, we include dummy variables for planning regions. Planning regions represent functionally integrated spatial units comprising several counties (NUTS 3 regions). They are a common spatial category for regional analysis and the assessment of regional infrastructures. Planning regions are comparable to labor market areas in the United States; each of the five East German Federal States (excluding Berlin) in the analysis comprises several planning regions. In total there are 22 planning regions included in the analysis. The fixed effects for planning regions also control for the proximity of a region to the city of Berlin that is obviously an important source of

[10] West German patents are assigned to the region in which the inventor claims his or her residence. If a patent has more than one inventor, the count is divided by the number of inventors and each inventor is assigned his or her share of that patent. Patent files for East Germany do not include the address of inventors, but their workplace instead. Hence, we assigned the East German patents to the location of the inventor's workplace.

[11] Data is from the Federal Statistical Office. https://www.destatis.de

[12] Data on the regional capital stock in the year 1996 are estimates of the Halle Institute for Economic Research. For a brief description, see Kubis, Titze and Brachert (2008).

development spillovers. Table A1 in the Appendix reports descriptive statistics for the variables in the analysis and Table A2 shows correlations among them.

5. Empirical Analysis

5.1 The role of initial conditions in East Germany

Table 1 shows the results of OLS regressions for the relationship between regional initial conditions in 1989 and the annual employment change in the 1989-2016 period. While all variables in Models 1 and 2 reflect the conditions in the final year of the socialist regime, we added indicators for capital inputs during the transition process in Models 3 and 4. As previously mentioned, the GDR capital stock (more or less zero) depreciated quickly (Sinn and Sinn, 1992), making the estimation of a production function in a turbulent transition context anything but reliable. Nevertheless, we want to control for concomitant investment during the early transition phase to rule out that these post-1989 factors are driving the results.

Table 1: Initial conditions and annual employment change, 1989-2016, in East German regions

Dependent variable: Employment change 1989-2016	(1)	(2)	(3)	(4)
Self-employment rate 1989	0.496***	0.446***	0.482***	0.407***
	(0.128)	(0.140)	(0.103)	(0.088)
Share of employees with university degree 1989	0.464***	0.460***	0.364 ***	0. 341***
	(0.092)	(0.090)	(0.101)	(0 .098)
Employment in 1989	-0.063*	-0.066*	-0.490**	-0.554***
	(0.037)	(0.038)	(0.177)	(0.174)
Share of employees in manufacturing 1989	-0.237	-0.230	-0.151	-0.117
	(0.152)	(0.147)	(0.103)	(0.098)
Share of large-scale industries in total manufacturing employment 1989		-0.027		-0.044*
		(0.031)		(0.025)
Average investment among manufacturing firms 1995			-0.037	-0.024
			(0.057)	(0.054)
Capital stock 1996			0.401**	0.454***
			(0.154)	(0.152)
Population density 1989	0.099*	0.113*	0.0 23	0.0 39
	(0.056)	(0.063)	(0.0 67)	(0.0 69)
Planning region fixed effects	Yes***	Yes***	Yes***	Yes***
Constant	3.606***	3.366***	7.322***	7.438***
	(0.836)	(0.901)	(1.704)	(1.636)
R-squared	0.823	0.829	0.874	0.889

Notes: OLS regressions with 55 observations (regions); robust standard errors in parentheses. ***: statistically significant at the 1% level: **: statistically significant at the 5% level; statistically significant at the 10% level.

In line with our expectations the level of self-employment in 1989 and the share of employees with a university degree are significantly positively related to employment growth. The employment share in large-scale industries is only weakly significant in Model 4, where we control for capital inputs. While the average investment among manufacturing firms remains statistically insignificant, we find significantly positive coefficients for the estimates of the regional capital stock in 1996. Inclusion of the two variables for capital inputs leads to a moderate increase of the R^2 value of 0.051 and 0.06, respectively. Population density in 1989 is only weakly significant with a positive sign in models that do not include variables for capital inputs. Planning region fixed effects are highly significant in all models.[13]

Table 2: Initial conditions and change of GDP per population 1992-2016 in East German regions

Dependent variable: GDP growth 1992-2016	(1)	(2)	(3)	(4)
Self-employment rate 1989	0.459***	0.371**	0.456***	0.374**
	(0.140)	(0.142)	(0.152)	(0.148)
Share of employees with university degree 1989	0.470***	0.451***	0.463***	0.441***
	(0.147)	(0.131)	(0.165)	(0.149)
GDP level 1992	-0.666**	-0.641**	-0.718**	-0.695**
	(0.254)	(0.233)	(0.302)	(0.272)
Share of employees in manufacturing 1989	0.127	0.150	0.125	0.155
	(0.175)	(0.171)	(0.188)	(0.183)
Share of large-scale industries in total manufacturing employment 1989		-0.050		-0.050
		(0.038)		(0.039)
Average investment among manufacturing firms 1995			-0.011	0.001
			(0.089)	(0.086)
Capital stock 1996			0.034	0.035
			(0.070)	(0.066)
Population density 1989	-0.008	0.012	-0.038	-0.016
	(0.075)	(0.075)	(0.112)	(0.105)
Planning region fixed effects	Yes***	Yes***	Yes***	Yes***
Constant	-1.583	-1.988	-2.642***	-2.998**
	(1.274)	(1.240)	(0.771)	(1.348)
R-squared	0.727	0.748	0.756	0.603

Notes: OLS regressions with 55 observations (regions); robust standard errors in parentheses. ***: statistically significant at the 1% level: **: statistically significant at the 5% level; statistically significant at the 10% level.

[13] The significantly negative coefficient for the employment level in 1989 indicates a 'regression to the mean' effect, i.e., regions with high levels of employment have lower scope for employment growth.

Models that include the annual GDP growth in the period 1992 to 2016 (Table 2), lead to rather similar results. Both the self-employment rate and the share of employees with a university degree in 1989 are highly significant with a positive sign. The highly significant negative coefficients for GDP per capita in 1992 indicate the common convergence phenomenon that regions with low levels show higher growth rates. The indicators for industry structure and population density in 1989 remain insignificant. Also, no significant effect is found for the two measures for capital inputs (Models 3 and 4), while the planning region dummies are again highly significant.

The estimates confirm our basic hypothesis that the initial conditions, in terms of remaining self-employment at the end of the socialist period and the qualification level of the regional workforce, are the main drivers of growth in East German regions during the transition period. The results are largely robust when running the models for the sub-periods 1989/1992-2000 and 1989/1992-2008 (see Tables A3 to A6 in the Appendix). A main difference between the models for annual employment change is that the effect of the initial conditions in the year 1989 is comparatively small in the particularly turbulent first decade (1989-2000, Table A3) of the transformation process and becomes slightly larger when extending the assessed period (1992-2008, Table A4), while the coefficient estimates are strongest when assessing the full period (Table 1). This pattern indicates that there was considerable 'transition noise' in the first years after the regime switch masking the effect of knowledge and entrepreneurship. Hence, the effect of initial conditions is not fading out, but becomes even stronger over time. Models with GDP change as the dependent variable reveal a similar pattern. For the early transition period (1992-2000, Table A5), the effect of the self-employment rate is actually insignificant, but the effect becomes stronger and more significant if we extend the assessment period (1992-2008, Table A6 & 1992-2016, Table 2).

5.2 Comparison with the well-established West German economy

Our models show that the effect of initial conditions, in terms of entrepreneurship and knowledge, plays an important role for regional development in the turbulent times of a transition from a planned socialist economy to a market-based system in East Germany. In this section, we explore to what extent the same measures are also related to growth in West Germany over the same time period. Obviously, West

Germany was a fully-fledged market economy in 1989, and as such the notion of "initial conditions" does not carry the same significance in the West German context. Yet, by comparing the growth rates of both regions using the same variables and data, we will be able to test our conjecture that knowledge and entrepreneurship are drivers of growth in the context of a transition from socialism to a market economy (Section 3.2). The German case is particularly well-suited for a comparison because since unification both parts of the country are subject to basically the same framework of social institutions.

An issue with such a comparison is that the self-employment rate in 1989 in West Germany probably reflects a regional entrepreneurial culture or tradition to a lesser degree than in the East. A main reason is that self-employment in the West German context comprises a significant share of necessity entrepreneurship that is induced by unemployment, or the threat thereof. Assuming that necessity entrepreneurship is unlikely to be innovative and growth-enhancing, the self-employment rate in West Germany may to a lesser degree indicate key elements of productive entrepreneurship, such as initiative and a desire for self-realization. This is in stark contrast to socialist countries where everyone had a constitutional right to be in dependent employment, and necessity entrepreneurship driven by the fear of being unemployed was not a motive for remaining or becoming self-employed.[14]

As previously mentioned, being self-employed, despite severe anti-entrepreneurial propaganda and policies in socialism, indicates a relatively strong entrepreneurial orientation. Hence, a high local share of self-employed people in a socialist regime is indicative of an entrepreneurial culture that has pre-socialist origins (e.g., Wyrwich 2012, for details). Thus, we expect that the self-employment rate plays a much more positive role for subsequent growth in the East German transition context, because it reflects a local entrepreneurship culture and the entrepreneurial potential of regions at the advent of transition. Whereas in West Germany, this rate captures not only self-employment that is due to entrepreneurial culture, but also self-employment driven by necessity and self-employment driven by any number of other reasons.

[14] It should be noted that the East German socialist regime allowed only very few entries of new private firms so that it was nearly impossible nearly to set up a legal private business. Hence, the great majority of the private businesses found in 1989 were remnants of the pre-socialist period.

We expect that our measure for the regional knowledge base (the share of employees with a tertiary degree) will have a stronger effect for West Germany. The reason is that the transformation process involved drastic changes to, for example, abandonment of technological paradigms and depreciation of a large portion of the knowledge stock in East Germany rendering this stock basically useless (Sinn and Sinn 1992; Berentsen 1992; Radosevic 1999)**.** In contrast, unification brought about only minor changes to the established market economy of West Germany. This suggests that the knowledge stock in East German regions at the end of the socialist period, as measured by the share of employees with a tertiary degree, should play a lesser role in explaining subsequent growth. Given the particular necessity of East Germans to learn and adjust, one may, however, assume that the relatively high level of absorptive capacity found in individuals with a tertiary degree gives regions with high shares of a well-qualified workforce a relative advantage.

We ran our models for East and West German regions together, including interaction terms for all regional conditions in 1989 with a dummy variable that assumes the value of 1 for regions located in East Germany, and 0 otherwise.[15] For the sake of brevity, we only report the results for the self-employment rate in 1989, and the share of employees with a university degree. While the coefficients of the self-employment rate and the share of employees with a university degree indicate the role of these factors in West Germany, the coefficients of the interaction terms represent the differences in the effect of these factors between East and West Germany.[16]

While the regional conditions, in terms of self-employment rate and share of employees with university degree, are statistically significant for employment growth in both parts of the country, the relatively high and statistically significant coefficients of the interaction terms clearly indicate particularly high relevance for the East German regions (Table 3, Panel A). Quite remarkably, the coefficients that

[15] Data on the regional self-employment rate, the share of employees with university degree, and the employment share in manufacturing in large scale manufacturing industries is from the employment statistic of the Federal Labor Office. Data on investment and population density is from the Federal Statistical Office, and the estimates of the capital stock in 1996 are from the Halle Institute for Economic Research (see Kubis, Titze and Brachert 2008). Unfortunately, there is no data for regional self-employment in West Germany in the year 1989 that is comparable to the values of the latter years. Therefore, we extrapolate data from 1991 to 1989.

[16] The sum of the coefficients of the base variable and of the respective interaction term represents the effect in East German regions.

Table 3: Regional conditions 1989 and annual employment/GDP growth 1989/1992-2016 in East and West German regions

	(1)	(2)	(3)	(4)
Dependent variable: Employment change 1989-2016				
Panel A				
Self-employment rate 1989	0.174**	0.174**	0.198**	0.196**
	(0.078)	(0.076)	(0.082)	(0.080)
Self-employment rate 1989 X East (Yes=1)	0.321**	0.272*	0.284**	0.211*
	(0.139)	(0.146)	(0.122)	(0.110)
Share of employees with a tertiary degree 1989	0.124***	0.125***	0.086**	0.084**
	(0.034)	(0.033)	(0.043)	(0.042)
Share of employees with a tertiary degree 1989 X East (Yes=1)	0.340***	0.335***	0.279***	0.257***
	(0.090)	(0.087)	(0.099)	(0.095)
Further variables X East (Yes=1)	Model (1) Table 1&2	Model (2) Table 1&2	Model (3) Table 1&2	Model (4) Table 1&2
R-squared	0.890	0.892	0.902	0.905
Dependent variable: GDP growth 1992-2016				
Panel B				
Self-employment rate 1989	-0.235*	-0.235*	-0.178	-0.179
	(0.129)	(0.122)	(0.123)	(0.119)
Self-employment rate 1989 X East (Yes=1)	0.694***	0.606***	0.634***	0.553***
	(0.181)	(0.176)	(0.182)	(0.175)
Share of employees with a tertiary degree 1989	0.099**	0.101***	0.064	0.067
	(0.039)	(0.038)	(0.048)	(0.047)
Share of employees with a tertiary degree 1989 X East (Yes=1)	0.371***	0.350***	0.399**	0.374***
	(0.139)	(0.123)	(0.153)	(0.138)
Further variables X East (Yes=1)	Model (1) Table 1&2	Model (2) Table 1&2	Model (3) Table 1&2	Model (4) Table 1&2
R-squared	0.748	0.755	0.766	0.772

Notes: OLS regressions with 283 (N=55: East; N=228: West) observations (regions); robust standard errors in parentheses. ***: statistically significant at the 1% level: **: statistically significant at the 5% level; statistically significant at the 10% level.

represent the effect of the 1989 self-employment rate in West Germany for subsequent GDP growth (Table 3, Panel B) are not statistically significant or only slightly significant with a negative sign, while the effect of self-employment (coefficient of the basic variable plus the interaction term) is clearly positive in East German regions. This result is consistent with our conjecture that entrepreneurship is much more important in a highly turbulent economic environment that has to cope with a radical regime switch (East Germany) than in the highly stable conditions of a well-established market economy that follows its growth trajectory (West Germany). The result may, however, be severely shaped by different meanings of the self-employment rates. While the self-employment rate in the East in 1989 clearly

measures entrepreneurship culture and entrepreneurial potential at the advent of transition, a considerable part of self-employment captured by the respective rate in West Germany may reflect necessity-based firms.

The regional knowledge base is positively related to employment growth in East and West Germany, and again the effect is significantly stronger across East German regions (Table 3, Panel A). The regional knowledge base has no robust positive effect on GDP growth in West Germany. Once accounting for capital input (Table 3, Panel B, Model 3 and 4), the coefficient estimates become insignificant. This confirms our earlier conjecture that the stock of knowledge in established market economies might be related to and shaped by capital investment. Be that as it may, what our results do show is that our measure for regional knowledge has a negligible effect on GDP growth in West Germany when accounting for capital input, while it is a crucial factor in Eastern Germany, despite the depreciation of large parts of the knowledge stock over the course of transition. A possible explanation for this finding is that a high-quality workforce is reflected in those individuals who have a highly absorptive learning capacity and the ability to recombine their human capital for productive use in a market economy. If higher levels of formal education indicate higher levels of human capital and prosperity-enhancing productivity at the individual level, this would translate into higher growth at the regional level. In the following section, we provide a test to corroborate this interpretation.

5.3 Robustness check: patenting as measure for regional knowledge

In the previous section, we used the share of people with a tertiary degree in Eastern Germany in 1989 as measure for the regional knowledge base. We argued that this indicator reflects the share of people with an above-average absorptive capacity and the ability to cope with the challenges of a radical transition. In particular, this general qualification level may be more relevant than specialized and technology-specific knowledge that partly became obsolete when new technologies were introduced. To test this expectation, we run the analysis using a measure of regional patenting activity (patents per employee) instead of the share of employees with a tertiary degree (Table 4, Panel A & C). This is based on the assumption that patenting reflects more the technology-specific knowledge in a region. Since both measures, share of population with a tertiary degree and number of patents per

employee, are correlated, we ran regressions with both measures as a "horse race" regression (Table 4, Panel B & D).[17]

Table 4: Initial conditions and annual employment and GDP growth 1989/1992-2016 in East German regions: including patenting activity

	(1)	(2)	(3)	(4)
Dependent variable: Employment change 1989-2016				
Panel A				
Self-employment rate 1989	0.441***	0.386**	0.452***	0.363***
	(0.153)	(0.157)	(0.118)	(0.095)
Patents per employee 1989	0.059	0.058	0.038	0.032
	(0.042)	(0.039)	(0.051)	(0.044)
Further variables	Model (1) Table 1&2	Model (2) Table 1&2	Model (3) Table 1&2	Model (4) Table 1&2
R-squared	0.701	0.708	0.806	0.829
Panel B				
Self-employment rate 1989	0.499***	0.448***	0.490***	0.413***
	(0.122)	(0.132)	(0.101)	(0.085)
Share of employees with a tertiary degree 1989	0.563***	0.561***	0.447***	0.427***
	(0.131)	(0.128)	(0.112)	(0.102)
Patents per employee 1989	-0.044	-0.045	-0.036	-0.038
	(0.038)	(0.036)	(0.040)	(0.035)
Further variables	Model (1) Table 1&2	Model (2) Table 1&2	Model (3) Table 1&2	Model (4) Table 1&2
R-squared	0.833	0.839	0.881	0.896
Dependent variable: GDP growth 1992-2016				
Panel C				
Self-employment rate 1989	0.472***	0.373**	0.465***	0.374**
	(0.145)	(0.141)	(0.158)	(0.149)
Patents per employee 1989	0.091**	0.087**	0.089*	0.085**
	(0.041)	(0.036)	(0.047)	(0.041)
Further variables	Model (1) Table 1&2	Model (2) Table 1&2	Model (3) Table 1&2	Model (4) Table 1&2
R-squared	0.682	0.708	0.684	0.710
Panel D				
Self-employment rate 1989	0.462***	0.374**	0.457***	0.375**
	(0.141)	(0.143)	(0.155)	(0.151)
Share of employees with a tertiary degree 1989	0.427**	0.403**	0.422**	0.399**
	(0.177)	(0.169)	(0.181)	(0.176)
Patents per employee 1989	0.015	0.016	0.014	0.015
	(0.044)	(0.042)	(0.045)	(0.042)
Further variables	Model (1) Table 1&2	Model (2) Table 1&2	Model (3) Table 1&2	Model (4) Table 1&2
R-squared	0.728	0.749	0.730	0.750

Notes: OLS regressions with 55 observations (regions); robust standard errors in parentheses. ***: statistically significant at the 1% level: **: statistically significant at the 5% level; statistically significant at the 10% level.

[17] The correlation for East Germany is r=0.61 and r=0.48 for West Germany.

Our results confirm this expectation. Patenting activity is not significantly related to employment growth in any of our empirical models (Table 4, Panel A & C). There is a significantly positive coefficient for the number of patents per employee in models for GDP growth (Table 4, Panel C) that, however, collapses completely when also considering the share of employees with a university degree (Table 4, Panel D).[18] It is quite interesting, that in the much more steadily developing economy of West Germany, the number of patents per employee is more significantly related to employment change than the share of employees with a university degree, particularly in models that include variables for physical capital (Table A7 in the Appendix, Panel C & B). The patent indicator is, however insignificant in the models for GEP growth (Table A7, Panel C & D).

6. Discussion

The results of our analysis clearly demonstrate the relevance of initial conditions, specifically the levels of entrepreneurship and knowledge, for regional growth in East Germany during the shock transformation from a socialist planned economy to a market-based economic system. Both measures of initial conditions, the regional self-employment rate at the end of the socialist period in the year 1989, as well as the share of workforce with a tertiary degree, have a significantly positive effect on regional development over a time period of 26 years. These relationships are rather robust for different subperiods and specifications. Quite remarkably, we find that the impact of initial conditions becomes even slightly stronger over time.

Indicators of the regional industry structure in the year 1989 remain insignificant. Population density as an indicator for agglomeration effects is slightly significant in only a few models and, hence, does not seem to play an important role. The latter finding is not surprising given the fundamental urban adjustment processes in the aftermath of transition, which make it unlikely that growth-promoting agglomeration externalities occurred to a large degree (for details, see Section 3.2.).

In West Germany, where there was already a well-established market economy in 1989, the self-employment rate and the share of employees with a university degree play a much lesser role for subsequent growth. Indeed, the

[18] We also consider patenting activity in East and West Germany. The results of the analysis are in line with the main results (Table A7).

relationship between the self-employment rate and GDP growth in West Germany is even negative in some specifications. The higher effect of the self-employment rate in East Germany not only indicates the importance of entrepreneurship in a fundamentally restructuring economy, but may be also be due to the fact that the self-employment rate in a socialist context is more reflective of an entrepreneurial culture and tradition than is the case in West Germany (for details, see Section 5.2, and Wyrwich 2012). The East German mark-up that we find for the share of highly qualified employees is quite remarkable since a considerable part of the knowledge stock of the socialist GDR depreciated after 1989 (for details, see Section 3.2). It is also astonishing that any positive influence of the knowledge stock on GDP growth in West Germany vanishes once we control for capital input and investment, while the positive effect of knowledge remains stable across Eastern regions.

7. Summary and Conclusions

7.1 Findings and policy implications

In our analysis of the development of East German regions after the regime switch from socialism to a market economy, we focused on the role played by the initial conditions that existed at the end of the socialist era on subsequent growth and development. The basic idea behind our approach is that in a constellation of disruptive changes, the initial levels of entrepreneurship and knowledge are key resources for coping with the challenges of the transition. An advantage of our approach is that it is a reliable way to identify causal relationships. We argue that in a highly turbulent environment where input-output relationships may be rather uncertain and unstable, our approach is much better suited for identifying the sources of growth than the estimation of a conventional production function. Focusing on initial conditions acknowledges that regional history is an important determinant of regional performance and shapes the response of the regional economy to external challenges.

Our analysis clearly shows that the Schumpeterian approach of explaining economic development based on entrepreneurship and knowledge is of rather significant importance in the turbulent environment of a transition. More generally, we can demonstrate that entrepreneurship and knowledge play a decisive role for growth in a setting marked by a major exogenous shock event that forced radical

changes. These results suggest that entrepreneurship and knowledge can significantly contribute to enhancing the resilience of regions that are confronted with disruptive shocks. In fact, East German regions that were well equipped with both resources recovered more quickly from the devastating changes caused by the transformation process. Running the same type of analysis for the well-established and relatively smoothly growing market economy of West Germany showed that the regional levels of entrepreneurship and knowledge at the outset of the respective period have a much less significant impact. This result suggests that entrepreneurship and knowledge are particularly important in a turbulent context that is accompanied by fundamental changes. The policy implications of these results are straightforward. In order to safeguard growth and welfare, countries and regions should attempt to create a favorable environment for new business formation and invest in their knowledge base.

7.2 Limitations and suggestions for further research

Our analysis is of course not without shortcomings. One of these shortcomings could be that our measure for the regional knowledge base (the share of workforce with a tertiary degree) is rather general. It indicates more the capacity to learn and absorb new knowledge than directly indicating economically relevant knowledge and innovative activity. However, the number of patents per 1,000 employees in the regional workforce that we tested as an alternative variable for the regional knowledge base represents to a considerable degree technology-specific knowledge that became obsolete and had to be depreciated after the demise of the socialist regime (Section 3.2). Other potential indicators of the regional knowledge base, such as the number of R&D personnel, number of students etc., are not meaningful in the East German case due to the radical changes in the organization of research that occurred immediately after the regime switch.

The most significant limitation of our analysis is the focus on just one country, Germany. Hence, it is unclear if, and to what extent the results hold for other former socialist countries of Central and Eastern Europe that also began a transformation to a market economic system in the early 1990s. Performing the same type of empirical analysis for these countries could indicate to what extent our results can be generalized. Since these countries applied quite different transformation strategies (see, for example Åslund and Djankov 2014, and Kollmorgen 2019), a

cross-country comparison that includes an analysis of the interaction between these strategies and the initial levels of entrepreneurship and workforce qualification at the end of the socialist period may provide a more comprehensive picture.

Our finding that the initial regional conditions of the levels of entrepreneurship and knowledge were important indicators of a region's ability to cope with the challenges of the extremely disruptive East German transformation process, leads us to wonder if this will hold true for other types of disruptive events, such as wars, natural disasters or a fundamental financial crisis. Do entrepreneurship and knowledge make regions more resilient to such shocks? Is it the actual level of self-employment or is it more an entrepreneurial tradition, culture or orientation of the population that is important in this respect?

Another key question is: Why do certain regions have a high level of entrepreneurship and/or a well-developed knowledge base? Obviously, historical research in regions that have pronounced levels of these characteristics would be required. Yet another question is: Do these high levels of regional entrepreneurship and knowledge can persist over time, and if so, to what extent and in what way? Previous research provides examples of regions where high levels of entrepreneurship survived major external shocks such as: devastating wars, the displacement of the local populations, or long periods of time when private economic initiative was illegal (Fritsch et al. 2019). This suggests the presence of a culture of entrepreneurship, and of a collective memory of such a culture. Much less is known, however, about the development of a regional knowledge base and persistence of innovative behavior. Throwing more light on these two questions should help with the key policy problem of how to achieve sustainable improvements of regional levels of entrepreneurship, knowledge and innovativeness. What can policy do to support these types of activity that are obviously so important for regional performance?

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Appendix

Table A1a: Correlation matrix: East Germany

		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
[1]	Annual GDP growth 1992-2016	1										
[2]	Employment growth 1989-2016	0.631	1									
		[0.000]										
[3]	Self-employment rate 1989	0.457	0.26	1								
		[0.000]	[0.056]									
[4]	Share of employees with university degree 1989	0.052	0.485	-0.278	1							
		[0.704]	[0.000]	[0.040]								
[5]	Patents per employee 1989	0.162	0.201	-0.038	0.611	1						
		[0.236]	[0.141]	[0.781]	[0.000]							
[6]	Share of employees in manufacturing 1989	0.086	-0.249	0.311	0.038	0.435	1					
		[0.534]	[0.066]	[0.021]	[0.783]	[0.001]						
[7]	Share of large-scale industries in total manufacturing employment 1989	-0.484	-0.376	-0.416	0.06	0.101	0.056	1				
		[0.000]	[0.005]	[0.002]	[0.665]	[0.464]	[0.684]					
[8]	Population density 1989	-0.073	0.031	0.12	0.445	0.525	0.662	0.127	1			
		[0.598]	[0.820]	[0.384]	[0.001]	[0.000]	[0.000]	[0.355]				
[9]	Employment in 1989	-0.22	0.099	-0.231	0.563	0.413	0.144	0.125	0.602	1		
		[0.106]	[0.471]	[0.090]	[0.000]	[0.002]	[0.295]	[0.364]	[0.000]			
[10]	GDP level 1992	-0.274	0.421	-0.284	0.733	0.343	-0.095	0.165	0.342	0.579	1	
		[0.043]	[0.001]	[0.035]	[0.000]	[0.010]	[0.490]	[0.227]	[0.011]	[0.000]		
[11]	Average investment among manufacturing firms 1995	-0.268	-0.07	-0.511	0.074	0.062	-0.375	0.207	-0.22	0.082	0.132	1
		[0.048]	[0.612]	[0.000]	[0.592]	[0.652]	[0.005]	[0.130]	[0.107]	[0.554]	[0.337]	
[12]	Capital stock 1996	-0.161	0.257	-0.306	0.645	0.431	0.018	0.142	0.539	0.964	0.688	0.142
		[0.240]	[0.058]	[0.023]	[0.000]	[0.001]	[0.899]	[0.299]	[0.000]	[0.000]	[0.000]	[0.302]

Table A1b: Correlation matrix: West Germany

		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
[1]	Annual GDP growth 1992-2016	1										
[2]	Employment growth 1989-2016	0.78	1									
		[0.000]										
[3]	Self-employment rate 1989	0.113	0.205	1								
		[0.085]	[0.002]									
[4]	Share of employees with university degree 1989	-0.107	0.053	-0.357	1							
		[0.102]	[0.416]	[0.000]								
[5]	Patents per employee 1989	0.069	0.204	0.221	0.48	1						
		[0.295]	[0.002]	[0.001]	[0.000]							
[6]	Share of employees in manufacturing 1989	0.07	-0.155	-0.302	0.138	0.231	1					
		[0.284]	[0.018]	[0.000]	[0.035]	[0.000]						
[7]	Share of large-scale industries in total manufacturing employment 1989	-0.193	-0.047	0.069	0.083	0.111	-0.123	1				
		[0.003]	[0.470]	[0.291]	[0.207]	[0.091]	[0.060]					
[8]	Population density 1989	-0.21	-0.062	-0.299	0.773	0.5	0.183	0.121	1			
		[0.001]	[0.352]	[0.000]	[0.000]	[0.000]	[0.006]	[0.068]				
[9]	Employment in 1989	-0.16	-0.065	-0.507	0.726	0.222	0.083	0.022	0.828	1		
		[0.014]	[0.322]	[0.000]	[0.000]	[0.001]	[0.206]	[0.740]	[0.000]			
[10]	GDP level 1992	-0.083	-0.052	-0.512	0.599	0.191	0.218	-0.147	0.495	0.654	1	
		[0.206]	[0.433]	[0.000]	[0.000]	[0.003]	[0.001]	[0.024]	[0.000]	[0.000]		
[11]	Average investment among manufacturing firms 1995	0.088	0.122	-0.192	0.023	-0.126	-0.101	0.089	-0.043	0.012	0.075	1
		[0.179]	[0.063]	[0.003]	[0.727]	[0.054]	[0.124]	[0.174]	[0.521]	[0.860]	[0.256]	
[12]	Capital stock 1996	-0.121	0	-0.466	0.758	0.235	-0.009	0.033	0.823	0.967	0.661	0.053
		[0.065]	[0.996]	[0.000]	[0.000]	[0.000]	[0.887]	[0.613]	[0.000]	[0.000]	[0.000]	[0.421]

Table A2a: Summary statistics: East Germany

	Mean	Minimum	Maximum	Standard deviation
Annual GDP growth 1992-2016	0.108	0.076	0.196	0.023
Employment growth 1989-2016	0.737	0.511	1.191	0.148
Self-employment rate 1989	0.022	0.011	0.035	0.006
Share of employees with university degree 1989	0.061	0.037	0.124	0.018
Patents per employee 1989	10.001	1.1	61.999	9.642
Share of employees in manufacturing 1989	0.389	0.179	0.619	0.105
Share of large-scale industries in total manufacturing employment 1989	0.165	0.01	0.707	0.147
Population density 1989	0.274	-0.76	1.497	0.541
Employment in 1989	143000	40800	640000	114000
GDP level 1992	0.014	0.009	0.02	0.002
Average investment among manufacturing firms 1995	2.51	1.673	3.789	0.464
Capital stock 1996	2.522	1.109	4.247	0.729

Table A2b: Summary statistics: West Germany

	Mean	Minimum	Maximum	Standard deviation
Annual GDP growth 1992-2016	0.077	0.053	0.14	0.014
Employment growth 1989-2016	1.188	0.81	1.806	0.149
Self-employment rate 1989	0.084	0.048	0.143	0.015
Share of employees with university degree 1989	0.027	0.009	0.111	0.015
Patents per employee 1989	5.627	0.439	49.626	6.031
Share of employees in manufacturing 1989	0.263	0.056	0.543	0.082
Share of large-scale industries in total manufacturing employment 1989	0.14	0.002	0.74	0.11
Population density 1989	0.642	-0.931	2.903	0.735
Employment in 1989	129000	18755	1100000	162000
GDP level 1992	0.032	0.016	0.07	0.008
Average investment among manufacturing firms 1995	1.772	0.892	3.392	0.326
Capital stock 1996	2.999	1.44	6.241	0.907

Table A3: Initial conditions and annual employment change 1989-2000 in East German regions

Dependent variable: Employment change 1989-2000	(1)	(2)	(3)	(4)
Self-employment rate 1989	0.302***	0.301***	0.296***	0.272***
	(0.091)	(0.109)	(0.076)	(0.075)
Share of employees with university degree 1989	0.296***	0.296***	0.214***	0.207***
	(0.054)	(0.055)	(0.047)	(0.048)
Employment in 1989	-0.020	-0.020	-0.364***	-0.383***
	(0.030)	(0.031)	(0.095)	(0.098)
Share of employees in manufacturing 1989	-0.334***	-0.333***	-0.259***	-0.249***
	(0.112)	(0.112)	(0.085)	(0.084)
Share of large-scale industries in total manufacturing employment 1989		-0.001		-0.014
		(0.020)		(0.014)
Average investment among manufacturing firms 1995			-0.020	-0.016
			(0.029)	(0.029)
Capital stock 1996			0.321***	0.338***
			(0.083)	(0.085)
Population density 1989	0.063	0.063	0.003	0.009
	(0.044)	(0.050)	(0.038)	(0.042)
Planning region fixed effects	Yes***	Yes***	Yes***	Yes***
Constant	1.692***	1.686**	4.682***	4.718***
	(0.612)	(0.670)	(0.908)	(0.892)
R-squared	0.845	0.845	0.905	0.907

Notes: OLS regressions with 55 observations (regions); robust standard errors in parentheses. ***: statistically significant at the 1% level: **: statistically significant at the 5% level; statistically significant at the 10% level.

Table A4: Initial conditions and annual employment change 1992-2008 in East German regions

Dependent variable: Employment change 1989-2008	(1)	(2)	(3)	(4)
Self-employment rate 1989	0.410***	0.387***	0.396***	0.348***
	(0.108)	(0.124)	(0.082)	(0.076)
Share of employees with university degree 1989	0.398***	0.396***	0.301***	0.286***
	(0.073)	(0.074)	(0.073)	(0.072)
Employment in 1989	-0.058	-0.059	-0.474***	-0.515***
	(0.035)	(0.036)	(0.145)	(0.144)
Share of employees in manufacturing 1989	-0.295**	-0.291**	-0.210**	-0.189**
	(0.133)	(0.131)	(0.090)	(0.088)
Share of large-scale industries in total manufacturing employment 1989		-0.012		-0.029
		(0.027)		(0.021)
Average investment among manufacturing firms 1995			-0.035	-0.027
			(0.044)	(0.042)
Capital stock 1996			0.390***	0.425***
			(0.125)	(0.125)
Population density 1989	0.098*	0.104*	0.023	0.034
	(0.050)	(0.055)	(0.055)	(0.058)
Planning region fixed effects	Yes***	Yes***	Yes***	Yes***
Constant	2.916***	2.804***	6.535***	6.610***
	(0.704)	(0.772)	(1.393)	(1.352)
R-squared	0.826	0.828	0.889	0.898

Notes: OLS regressions with 55 observations (regions); robust standard errors in parentheses. ***: statistically significant at the 1% level: **: statistically significant at the 5% level; statistically significant at the 10% level.

Table A5: Initial conditions and change of GDP per population 1992-2000 in East German regions

Dependent variable: GDP growth 1992-2000	(1)	(2)	(3)	(4)
Self-employment rate 1989	0.146	0.084	0.154	0.095
	(0.095)	(0.111)	(0.102)	(0.115)
Share of employees with university degree 1989	0.283***	0.269***	0.261***	0.245***
	(0.074)	(0.072)	(0.082)	(0.078)
GDP level 1992	-0.463***	-0.446***	-0.580***	-0.564***
	(0.137)	(0.124)	(0.160)	(0.146)
Share of employees in manufacturing 1989	-0.046	-0.030	-0.035	-0.013
	(0.136)	(0.129)	(0.140)	(0.136)
Share of large-scale industries in total manufacturing employment 1989		-0.035		-0.036
		(0.034)		(0.033)
Average investment among manufacturing firms 1995			0.004	0.013
			(0.059)	(0.055)
Capital stock 1996			0.075*	0.075*
			(0.043)	(0.041)
Population density 1989	-0.074	-0.060	-0.135*	-0.119*
	(0.047)	(0.043)	(0.070)	(0.060)
Planning region fixed effects	Yes***	Yes***	Yes***	Yes***
Constant	-1.994**	-2.279***	-2.718***	-3.019***
	(0.797)	(0.813)	(0.825)	(0.841)
R-squared	0.681	0.704	0.699	0.724

Notes: OLS regressions with 55 observations (regions); robust standard errors in parentheses. ***: statistically significant at the 1% level: **: statistically significant at the 5% level; statistically significant at the 10% level.

Table A6: Initial conditions and change of GDP per population 1992-2008 in East German regions

Dependent variable: GDP growth 1992-2008	(1)	(2)	(3)	(4)
Self-employment rate 1989	0.340**	0.297*	0.349**	0.308*
	(0.151)	(0.148)	(0.156)	(0.151)
Share of employees with university degree 1989	0.424***	0.414***	0.416***	0.405***
	(0.121)	(0.119)	(0.131)	(0.129)
GDP level 1992	-0.658**	-0.646**	-0.682**	-0.670**
	(0.258)	(0.252)	(0.295)	(0.284)
Share of employees in manufacturing 1989	0.054	0.066	0.065	0.080
	(0.202)	(0.201)	(0.213)	(0.211)
Share of large-scale industries in total manufacturing employment 1989		-0.025		-0.026
		(0.035)		(0.036)
Average investment among manufacturing firms 1995			0.016	0.022
			(0.084)	(0.084)
Capital stock 1996			0.015	0.015
			(0.070)	(0.069)
Population density 1989	-0.050	-0.040	-0.059	-0.048
	(0.077)	(0.082)	(0.108)	(0.110)
Planning region fixed effects	Yes***	Yes***	Yes***	Yes***
Constant	-1.431	-1.630	-1.579	-1.793
	(1.355)	(1.380)	(1.588)	(1.598)
R-squared	0.627	0.633	0.628	0.635

Notes: OLS regressions with 55 observations (regions); robust standard errors in parentheses. ***: statistically significant at the 1% level: **: statistically significant at the 5% level; statistically significant at the 10% level.

Table A7: Regional conditions 1989 and annual employment/GDP change 1989/1992-2016 in East and West German regions including patenting activity

	(1)	(2)	(3)	(4)
Dependent variable: Employment change 1989-2016				
Panel A				
Self-employment rate 1989	0.068	0.066	0.114	0.110
	(0.083)	(0.082)	(0.086)	(0.084)
Self-employment rate 1989 X East (Yes=1)	0.373**	0.320*	0.338**	0.253**
	(0.162)	(0.163)	(0.135)	(0.118)
Patents per employee 1989	0.047***	0.049***	0.042**	0.045***
	(0.018)	(0.018)	(0.017)	(0.017)
Patents per employee 1989 X East (Yes=1)	0.012	0.009	-0.005	-0.013
	(0.042)	(0.039)	(0.048)	(0.042)
Further variables	Model (1) Table 1&2	Model (2) Table 1&2	Model (3) Table 1&2	Model (4) Table 1&2
R-squared	0.872	0.874	0.895	0.900
Panel B				
Self-employment rate 1989	0.132	0.130	0.149*	0.142*
	(0.081)	(0.079)	(0.085)	(0.082)
Self-employment rate 1989 X East (Yes=1)	0.367***	0.319**	0.341***	0.271**
	(0.136)	(0.141)	(0.122)	(0.110)
Share of employees with a tertiary degree 1989	0.103***	0.103***	0.059	0.056
	(0.037)	(0.036)	(0.044)	(0.042)
Share of employees with a tertiary degree 1989 X East (Yes=1)	0.461***	0.458***	0.388***	0.372***
	(0.123)	(0.119)	(0.107)	(0.098)
Patents per employee 1989	0.032*	0.034*	0.034**	0.037**
	(0.018)	(0.019)	(0.017)	(0.017)
Patents per employee 1989 X East (Yes=1)	-0.075**	-0.078**	-0.070*	-0.075**
	(0.038)	(0.037)	(0.039)	(0.035)
Further variables	Model (1) Table 1&2	Model (2) Table 1&2	Model (3) Table 1&2	Model (4) Table 1&2
R-squared	0.894	0.896	0.906	0.909
Dependent variable: GDP growth 1992-2016				
Panel C				
Self-employment rate 1989	-0.277**	-0.280**	-0.206	-0.210*
	(0.126)	(0.122)	(0.125)	(0.122)
Self-employment rate 1989 X East (Yes=1)	0.749***	0.654***	0.672***	0.584***
	(0.182)	(0.175)	(0.187)	(0.178)
Patents per employee 1989	0.020	0.023	0.020	0.022
	(0.020)	(0.021)	(0.020)	(0.021)
Patents per employee 1989 X East (Yes=1)	0.071*	0.064*	0.069	0.062
	(0.043)	(0.038)	(0.047)	(0.041)
Further variables	Model (1) Table 1&2	Model (2) Table 1&2	Model (3) Table 1&2	Model (4) Table 1&2
R-squared	0.736	0.743	0.758	0.764

Table A7 *continued*

Panel D				
Self-employment rate 1989	-0.242*	-0.245*	-0.190	-0.194
	(0.130)	(0.125)	(0.126)	(0.123)
Self-employment rate 1989 X East (Yes=1)	0.703***	0.619***	0.647***	0.569***
	(0.182)	(0.177)	(0.185)	(0.178)
Share of employees with a tertiary degree 1989	0.095**	0.095**	0.056	0.057
	(0.042)	(0.041)	(0.050)	(0.049)
Share of employees with a tertiary degree 1989 X East (Yes=1)	0.331**	0.308**	0.366**	0.342**
	(0.164)	(0.155)	(0.165)	(0.159)
Patents per employee 1989	0.006	0.009	0.011	0.014
	(0.020)	(0.022)	(0.020)	(0.021)
Patents per employee 1989 X East (Yes=1)	0.009	0.007	0.003	0.001
	(0.045)	(0.043)	(0.044)	(0.042)
Further variables	Model (1) Table 1&2	Model (2) Table 1&2	Model (3) Table 1&2	Model (4) Table 1&2
R-squared	0.749	0.755	0.766	0.772

Notes: OLS regressions with 283 (N=55: East; N=228: West) observations (regions); robust standard errors in parentheses. ***: statistically significant at the 1% level: **: statistically significant at the 5% level; statistically significant at the 10% level.

IMPRESSUM
Jena Economic Research Papers
ISSN 1864-7057
Friedrich Schiller University Jena
Faculty of Economics and Business Administration
Carl-Zeiss-Str. 3
D-07743 Jena, Germany

Email: office.jerp@uni-jena.de
Editor: Silke Übelmesser
Website: www.wiwi.uni-jena.de/en/jerp

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