Analysis of productivity in East-West German states (2011-2020): The Industrial Productivity Wall

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[1] Not including appendixes, bibliography, figure labels, formulas, and tables.

Introduction

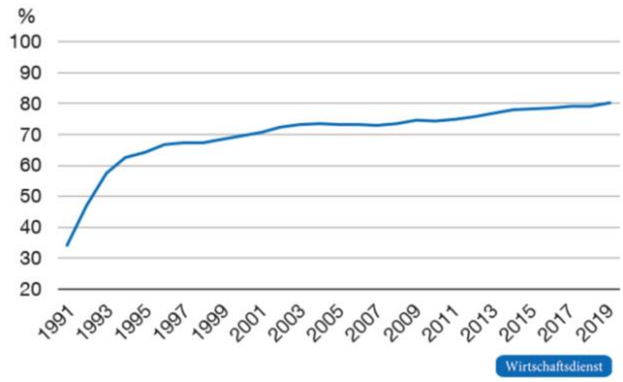
More than 30 years since the fall of the Berlin Wall, current unemployment, growth, or welfare indicators reveal that the economic situation in the former communist East Germany (DDR) remains economically behind the West. Labour productivity is considered as a key cause of these differences (Burda and Hunt 2001; Snower and Merkl 2006). This paper expands on a comparative firm-level approach, by aggregating data from Amadeus (2011-2020) of firms in East and West Germany. We use productivity measurements by Olley and Pakes (1996) and Levinsohn and Petrin (2003)[2]. Likewise, we investigate the elasticity of substitution labour/capital, using the method by Kmenta (1967). Our results indicate that the productivity of West German states is notably higher, likewise we note a higher elasticity of factors of production in East German firms.

[2] Referred to as OP and LP, respectively.

Literature review

After the fall of the Berlin Wall in 1989, a new separation was apparent to many economists: productivity growth (Akerlof et al, 1991). Indeed, even if during the first years of the united Germany, GDP per capita and productivity of East Germany grew exponentially, the convergence slowed down.

Figure 1: Labour productivity in East Germany (Müller, 2021)



Gross domestic product per employee, West Germany = 100

Mertens and Müller (2020) find labour productivity in the East, calculated as value added per person employed, to be less than 80% than in the West. The productivity difference is found in unproductive eastern companies, not by the lack of "top" companies in the old DDR. Using density-functions of the productivity distribution, they find a "left shift of the entire German productivity" (Müller, 2021).

Productivity is often defined as the difference between observed output and the predicted output, as per a Cobb-Douglas production function using an OLS regression. We use the tools of an OLS regression, assuming constant returns to scale, and that of Kmenta, calculating the observed elasticity of substitution (labour/capital). Working with Kmenta allows to determine specific values for the elasticity of substitution of factors of production

Cobb-Douglas and Kmenta calculations suffer from simultaneity and selection biases (Olley and Pakes, 1996). On one hand, simultaneity comes about because productivity is only known to the firm that is choosing their input levels while profit-maximising, and not to the economist. Firms might, therefore, increase or decrease the use of their inputs because of possible changes in perceived productivity. OLS does not account for such unobserved changes in productivity; a fixed-effect (by firm) estimator can also not account for these differences because productivity shocks are time-variant. On the other hand, selection bias comes from the probability of (not) exiting the market. For example, if firms with higher accumulated capital are expected to have higher profits in the future, despite negative productivity shocks, they might be more likely to not exit the market than a firm with less capital in a similar situation (ibid). We can expect that selection bias will cause the capital estimate in an OLS to be lower than the actual value.

Olley and Pakes (1996) developed an approach solve for simultaneity bias; it uses productivity as an unobserved proxy for productivity shocks. The selection bias is addressed through considering survival (exit) probabilities. OP assumes those firms that know that they are productive, because of the shocks, will invest more, and vice versa. LP develop the OP model by using an instrumental variable (material or energy costs), instead of investment. They claim that investment is not the best proxy as there might be observations with zero investment (Levinson and Petrin, 2003). Previous productivity estimates of East/West-German firms by Mertens and Müller (2020) are based on OP, but they do not develop a complete OP model, nor they calculate the elasticity (Kmenta) or the LP estimates.

Empirical study

To analyse differences in productivity we used firm-level information from West and East German states, taken from the Amadeus dataset. Only firms with data from at least two years of all our selected variables in the following East/West states have been selected, as to control for firms with high quality of data.

We study firms in four West German states (Nordrhein-Westfalen, Niedersachsen, Hessen, Schleswig-Holstein) and five East German states (all ex-DDR states, except Berlin). We chose these West German states, as they are all in the same Northeast region and geographically close to East Germany. Following Mertens and Müller (2020), we control for size, sector of the firms, age and Federal State:

Table 1: Description of variables

Added value *	Proxy for production ($X_{i,t}$)
Tangible fixed assets *	Proxy for capital ($K_{i,t}$)
Number of employees	Proxy for labour ($L_{i,t}$)
Material costs *	Proxy for differences in inputs, and size, of the firm, used as the main proxy for productivity in LP and as a control for (input/firm) size ($MC_{i,t}$)
Dummy for sector (US SIC primary code)	Dummy for the primary code of the sector, used as a control and to create inflation estimators ($SECTOR_{i,t}$)
Dummy for regions (German states)	Dummy for specific regional effects ($REGION_{i,t}$)
Age	Calculated using the year of establishment of each firm, as reported in Amadeus. ($AGE_{i,t}$)

Nominal values (*) are deflated using sector-specific estimators following indications by Appendix A. We present here a summary of our deflated variables:

Table 2: Descriptive statistics of firms in West German States

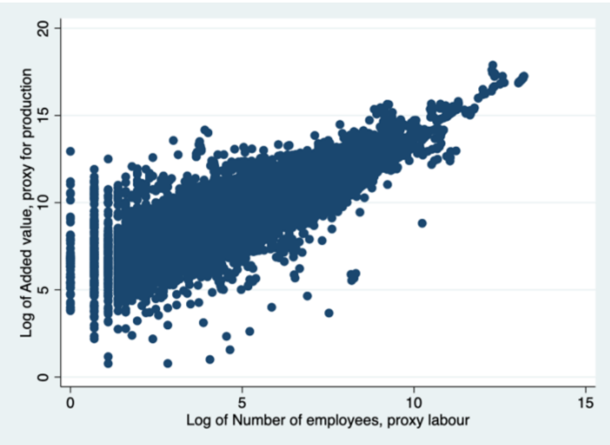
	Count	Mean	Standard Dev.	Min.	Max.
Addedvalue	57168	63309.75	700342.8	-671900	5.85e+07
Tangiblefixedassets	57122	59496.3	778422	0	9.35e+07
Numberofemployees	54924	926.4445	8989.034	1	541888
Materialcosts	48981	126074.4	848332.3	-16007.07	7.41e+07
Age	57168	46.97674	37.57751	0	651

Table 3: Descriptive statistics of firms in East German States

	Count	Mean	Standard Dev.	Min.	Max.
Addedvalue	16113	24459.92	103142.8	-163785.5	7072475
Tangiblefixedassets	16100	40107.36	171088.9	0	4857540
Numberofemployees	15305	310.3207	530.7158	1	7907
Materialcosts	13668	40042.82	212593	-3343.396	1.06e+07
age	16113	30.027	15.04053	2	317

All values are later transformed into logs to obtain proper regression estimators. We run a series of simple scatter graphs for both datasets:

Figure 3: Added value, and capital and labour proxies for West German States



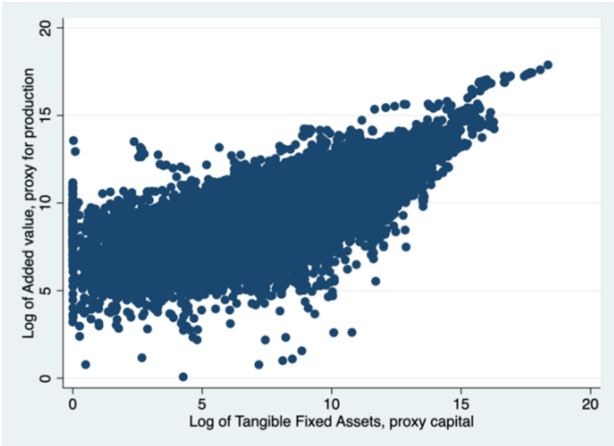
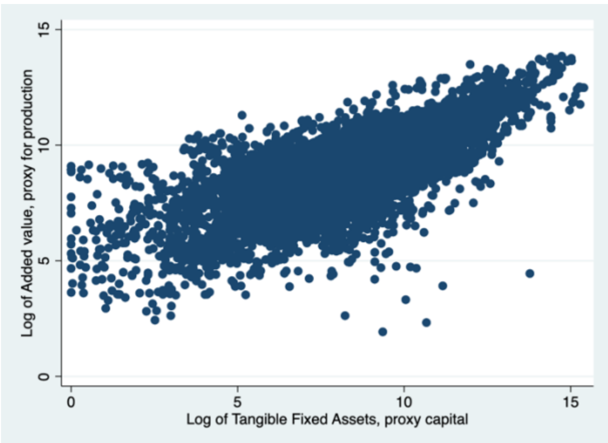
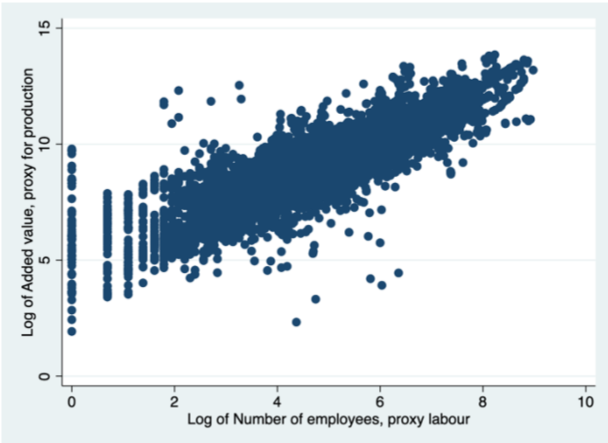


Figure 4: Added value, and capital and labour proxies for East German States





We see that capital is more present in West German companies and the expected positive relationship between capital/labour and productivity. We run an OLS regression, with controls as per Yasar et al (2008):

$$MODEL\ 1:$$

$$log\hat{X}_{i,t} = \hat{\beta}_0 + \hat{\beta}_K logK_{i,t} + \hat{\beta}_L logL_{i,t} + \hat{\beta}_S SECTOR_{i,t} + \hat{\beta}_R REGION_{i,t} + \hat{\beta}_{MC} logMC_{i,t} + \hat{\beta}_{AGE} AGE_{i,t}$$

To control for firms' heterogeneity, we repeat this OLS regression with within-group fixed effects, controlling for year-specific effects:

$$MODEL\ 2:$$

$$log\hat{X}_{i,t} = \hat{\beta}_0 + \hat{\beta}_K logK_{i,t} + \hat{\beta}_L logL_{i,t} + \hat{\beta}_S SECTOR_{i,t} + \hat{\beta}_R REGION_{i,t} + \hat{\beta}_{MC} logMC_{i,t} + \hat{\beta}_t t + \hat{\beta}_{AGE} AGE_{i,t}$$

We develop this model controlling for non-constant elasticities, using the Kmenta model. We generate the K variable, defined as $[logK_i - logL_i]^2$ and repeat model 2 now accounting for K. We reduce the number of controls, following past literature (Gechert et al, 2021)

$$MODEL\ 3:$$

$$log\hat{X}_{i,t} = \hat{\beta}_0 + \hat{\beta}_K logK_{i,t} + \hat{\beta}_L logL_{i,t} + \hat{\beta}_{km} k + \hat{\beta}_S SECTOR_{i,t} + \hat{\beta}_R REGION_{i,t} + \hat{\beta}_t t$$

With the values of the estimators $\hat{\beta}_1$ $\hat{\beta}_2$ and $\hat{\beta}_3$, we follow the steps at Appendix D to find the following elasticities of substitution:

West: 0.10727056

East: 0.686652581

Lastly, we develop our OP and LP regressions. We follow the steps presented in Yasar et al (2008). First, we create our main proxy variable (investment), using the method by Gal (2013). As we lack data on depreciation of capital for our observations (Amadeus only provides "Amortisation & Depreciation"), we calculate investment as the difference of capital between years:

$$INVESTMENT_i = K_{i,t} - K_{i,t-1}$$

Likewise, we develop a proxy for "exit", establishing a dummy when the firm exists. For this we remove all observations without any data, and we identify them as a period when the firm "exited". Using Material Cost, sector, age, and region as controls, we develop the following regression (Yasar et al, 2008):

$$MODEL\ 4:$$

$$log\hat{X}_{i,t} = \hat{\beta}_0 + \hat{\beta}_L logL_{i,t} + \hat{\beta}_K logK_{i,t} + \hat{\beta}_{MC} logMC_{i,t} + \hat{\beta}_S SECTOR_{i,t} + \hat{\beta}_R REGION_{i,t} + \beta_A logAGE_{i,t} + \beta_I logINVESTMENT_{i,t} + \eta_{i,t} + \omega_{i,t}$$

$$where\ \ \eta_{i,t}\ is\ the\ measurement\ error\ term,$$

$$and\ \omega_{i,t}\ is\ productivity\ and\ respects\ the\ invertibility\ condition$$

$$\omega_{i,t} = \ h_{i,t}(logINVESTMENT_{i,t}, AGE_{i,t}, logK_{i,t})$$

To control for the possible issues of using investment as a proxy, namely zero and negative investment, we also develop the LP model, as explored in Petrin et al (2004). Because of the restrictions of the command, we do not control for sector, age, or region:

$$MODEL\ 5:$$

$$log\hat{X}_{i,t} = \hat{\beta}_0 + \hat{\beta}_L logL_{i,t} + \hat{\beta}_K logK_{i,t} + \hat{\beta}_{MC} logMC_{i,t} + \eta_{i,t} + \omega_{i,t}$$

$$where\ \ \eta_{i,t}\ is\ the\ measurement\ error\ term,$$

$$and\ \omega_{i,t}\ is\ productivity\ and\ respects\ the\ invertibility\ condition$$

$$\omega_{i,t} = \ h_{i,t}(logMC_{i,t}, AGE_{i,t}, logK_{i,t})$$

Table 4: Results of regressions for firms in selected states in West Germany (2011-20)					
	(1)	(2)	(3)	(4)	(5)
	OLS	OLS fixed eff.	OLS fe, k	OP	LP
main	*lnaddedvalue*	*lnaddedvalue*	*lnaddedvalue*	*lnaddedvalue*	*lnaddedvalue*
lnnemployees	0.635***	0.308***	0.495***	0.614***	0.631***
	(0.00262)	(0.00565)	(0.00680)	(0.0104)	(0.00843)
lntanassets	0.118***	0.0770***	0.0400***	0.0654***	0.0723***
	(0.00180)	(0.00334)	(0.00412)	(0.0179)	(0.0153)
lnmaterialcosts	0.116***	0.156***		0.0973***	
	(0.00163)	(0.00314)		(0.00567)	
age	-0.000109	0.0190***		0.0000324	
	(0.0000723)	(0.000782)		(0.00399)	
2011.year		0			
		(.)			
2012.year		-0.0186**	-0.00602		
		(0.00580)	(0.00590)		
2013.year		-0.0286***	0.000924		
		(0.00553)	(0.00587)		
2014.year		-0.0179**	0.0312***		
		(0.00553)	(0.00596)		
2015.year		-0.0105	0.0585***		
		(0.00541)	(0.00590)		

2016.year		0.000743	0.0898***		
		(0.00530)	(0.00579)		
2017.year		0.0150**	0.121***		
		(0.00535)	(0.00568)		
2018.year		0.0152**	0.140***		
		(0.00552)	(0.00567)		
2019.year		0.0131*	0.159***		
		(0.00584)	(0.00574)		
2020.year		0	0.154***		
		(.)	(0.00686)		
k			0.0124***		
			(0.000624)		
_cons	4.083***	4.963***	6.400***		
	(0.0203)	(0.0508)	(0.0311)		
N	46746	46746	54462	49060	46746
R^2	0.841	0.272	0.258		
adj. R^2	0.841	0.119	0.126		

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Regressions 1, 2, 3 and 4 include region and sector dummy controls, see the results of these in Appendix C.

Table 5: Results of regressions for firms in selected states in East Germany (2011-20)					
	(1)	(2)	(3)	(4)	(5)
	OLS	OLS fixed eff.	OLS fe, k	OP	LP
main	*lnaddedvalue*	*lnaddedvalue*	*lnaddedvalue*	*lnaddedvalue*	*lnaddedvalue*
lnnemployees	0.629***	0.428***	0.585***	0.540***	0.622***
	(0.00482)	(0.0131)	(0.0165)	(0.0217)	(0.0135)
lntanassets	0.174***	0.0900***	0.0515***	0.201**	0.127***
	(0.00325)	(0.00747)	(0.0105)	(0.0711)	(0.0383)
lnmaterialcosts	0.119***	0.155***		0.114***	
	(0.00302)	(0.00627)		(0.0122)	
age	0.000658*	0.0211***		-0.00263	
	(0.000293)	(0.00140)		(0.00817)	
2011.year		0	0		
		(.)	(.)		
2012.year		-0.0232*	-0.00435		
		(0.0103)	(0.0102)		
2013.year		-0.0141	0.0261*		
		(0.00990)	(0.0102)		
2014.year		-0.0153	0.0448***		
		(0.0100)	(0.0104)		
2015.year		-0.0103	0.0657***		
		(0.00983)	(0.0103)		

2016.year		-0.00155	0.102***		
		(0.00962)	(0.0101)		
2017.year		0.000447	0.124***		
		(0.00981)	(0.00994)		
2018.year		-0.00547	0.142***		
		(0.0101)	(0.00991)		
2019.year		-0.0114	0.163***		
		(0.0107)	(0.0100)		
2020.year		0	0.189***		
		(.)	(0.0119)		
k			0.0108***		
			(0.00151)		
_cons	3.246***	4.231***	5.478***		
	(0.0324)	(0.0908)	(0.0702)		
N	12886	12886	15176	9933	12886
R^2	0.857	0.282	0.265		
adj. R^2	0.857	0.129	0.134		

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Regressions 1, 2, 3 and 4 include region and sector dummy controls, see the results of these in Appendix D.

Discussion of results and conclusion

Our regression estimators are statistically significant in all but for some control variables (year, age, region, and sector). Model 1 shows marginally higher labour estimator in the West. The regression estimates of model 2-3 for labour indicate lower productivity in West than East firms. Nevertheless, the OP and LP results, controlling for simultaneity and selection biases, prove the main hypothesis: labour productivity is higher in firms located in the West than in the East. Likewise, the estimates for capital are significantly lower in both East and West firms in Models 1-3 than in 4-5, this coincides with conclusions from Yasar et al (2008), that indicates "the selection bias causes […] the capital coefficient to be biased [in an OLS regression]" (pp.224).

Overall, simultaneity and selection biases in OLS estimates push the Western states labour and capital coefficients more downwards than for Eastern German firms. The difference between OLS (Model 1,2,3) and OP/LP (4,5) is more notable in the case of OP (West: 0.614, East: 0.540) than LP (West: 0.631, East: 0.622), this could be due to the fact of the more controls in OP than LP. Indeed, we note, some of the dummies in OP for sectors, region and Material Costs are statistically significant.

We find relatively higher elasticity of substitution in East than West German firms. This can be explained by the differences in sectorial structure and firm heterogeneity. Further studies using Kmenta with similar observations per region (West/East) in the same industries could be proposed, as to investigate elasticity in industry-by-industry cases. Estimators show typical of complementary goods (positive elasticity) and lower than Constant Elasticities (Elasticity=1), showing that the results in Model 1 and 2 (that do not control for non-consent elasticities) are biased.

We acknowledge limitations and improvements for future research. Firstly, we note the number of observations in West states is almost four times than in East states; this might have affected the quality of data in East firms, even if our indicators remained statically significant. Although we controlled for year fixed and sector fixed effects, inflation estimates could have been more elaborate. Furthermore, notable differences in sectorial structure between regions could have been better controlled for, adding more US-SIC digits. To tackle this issue, an interesting extension is the study of specific sector in East-West German firms, like Patuelli et al (2010) on nanomaterials. Another limitation has been the investment proxy for the OP regression: as we did not consider depreciation, investment might have been overestimated in our coefficients.

Our results show the general trend shown by previous studies by Mertens and Müller (2020) on different East/West productivity and give interesting insights into selection and simultaneity biases, as well as on elasticity of substitution, that could be a matter for further comparative study.

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Appendix A: Inflation estimators

Range of SIC codes	Description	Inflation estimator
0100-0999	Agriculture, Forestry & Fishing	Agriculture Price Index
1000-1799	Construction & Mining	Construction Price Index
2000-3999	Manufacturing	Manufacturing Price Index
4000-4999	Transport & Energy services	Transport (incl. fuel prices) Index
5000-5999	Wholesale Trade	Wholesale Price Index
6000-9999	Services, including public administration and finance	Service Price Index

Note: all inflation estimators have been retrieved from the German statistical institute: Destastis, all available online.

We develop the following graphs by SIC primary code. There are notable differences in the industrial structure of each region:

Figure A.1: SIC codes in West German firms

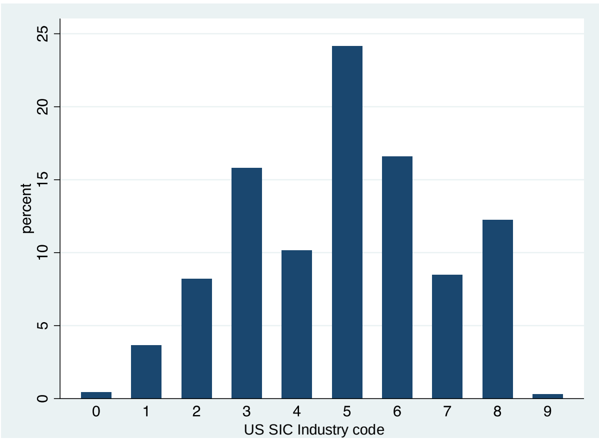
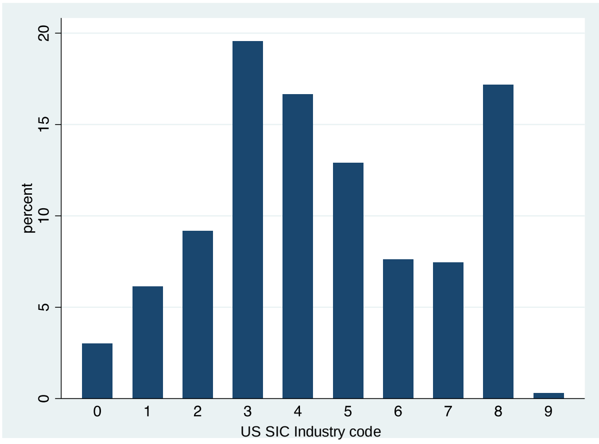


Figure A.2: SIC codes in East German firms



Appendix B: Complete regression table – West German states

	(1) lnaddedvalue	(2) lnaddedvalue	(3) lnaddedvalue	(4)	(5) lnaddedvalue
main					
lnnemployees	0.635***	0.308***	0.495***	0.614***	0.631***
	(0.00262)	(0.00565)	(0.00680)	(0.0104)	(0.00843)
lntanassets	0.118***	0.0770***	0.0400***	0.0654***	0.0723***
	(0.00180)	(0.00334)	(0.00412)	(0.0179)	(0.0153)
region1	0.128***	0	0	0.106***	
	(0.0120)	(.)	(.)	(0.0285)	
region2	-0.0725***	0	0	-0.0675**	
	(0.0119)	(.)	(.)	(0.0242)	
region3	0.0380***	0	0	0.0297	
	(0.0109)	(.)	(.)	(0.0204)	
sector1	-0.215***	0	0	-0.241***	
	(0.0430)	(.)	(.)	(0.0729)	
sector2	0.172***	0	0	0.137**	
	(0.0183)	(.)	(.)	(0.0437)	
sector4	0.0210	0	0	0.0382	
	(0.0117)	(.)	(.)	(0.0219)	
sector5	0.210***	0	0	0.103***	
	(0.0129)	(.)	(.)	(0.0294)	

sector6	-0.155***	0	0	-0.155***
	(0.0112)	(.)	(.)	(0.0234)
sector7	0.0765***	0	0	0.0332
	(0.0116)	(.)	(.)	(0.0230)
sector8	0.102***	0	0	0.0561
	(0.0138)	(.)	(.)	(0.0340)
sector9	0.0696***	0	0	0.0142
	(0.0129)	(.)	(.)	(0.0259)
sector10	0.0119	0	0	-0.113
	(0.0490)	(.)	(.)	(0.0858)
lnmaterialcosts	0.116***	0.156***		0.0973***
	(0.00163)	(0.00314)		(0.00567)
age	-0.000109	0.0190***		0.0000324
	(0.0000723)	(0.000782)		(0.00399)
2011.year				
2012.year		-0.0186**	0	
		(0.00580)	(.)	
2013.year		-0.0286***	-0.00602	
		(0.00553)	(0.00590)	

2014.year		-0.0179**	0.000924	
		(0.00553)	(0.00587)	
2015.year		-0.0105	0.0312***	
		(0.00541)	(0.00596)	
2016.year		0.000743	0.0585***	
		(0.00530)	(0.00590)	
2017.year		0.0150**	0.0898***	
		(0.00535)	(0.00579)	
2018.year		0.0152**	0.121***	
		(0.00552)	(0.00568)	
2019.year		0.0131*	0.140***	
		(0.00584)	(0.00567)	
2020.year		0	0.159***	
		(.)	(0.00574)	
k			0.154***	
			(0.00686)	
_cons	4.083***	4.963***	0.0124***	
	(0.0203)	(0.0508)	(0.000624)	
PROBIT				
L.Age				1.012
				(0.789)
L.lntanassets				18.71
				(22.23)

L.lninvestment_Age	-0.0661
	(0.0515)
L.lninvestment_lntanassets	-1.221
	(1.451)
L.Age_lntanassets	0.0000908
	(0.000142)
L.lninvestment_sq	0.702
	(0.731)
L.Age_sq	0.00000232
	(0.00000644)
L.lntanassets_sq	-0.00304**
	(0.00118)
L.region1	-0.0428
	(0.0411)
L.region2	0.0184
	(0.0397)
L.region3	-0.0108
	(0.0388)

L.sector1	-0.153
	(0.184)
L.sector2	0.0180
	(0.0624)
L.sector4	0.0151
	(0.0411)
L.sector5	-0.0888*
	(0.0351)
L.sector6	-0.0440
	(0.0387)
L.sector7	0.0933*
	(0.0388)
L.sector8	0.0696
	(0.0403)
L.sector9	0.0435
	(0.0446)
L.sector10	-0.0262
	(0.210)
_cons	-166.4
	(171.7)
PARTLIN	
Age	0.124

	(0.157)
lntanassets	-17.07*
	(7.069)
lnnemployees	0.614***
	(0.0104)
lnmaterialcosts	0.0973***
	(0.00567)
region1	0.106***
	(0.0285)
region2	-0.0675**
	(0.0242)
region3	0.0297
	(0.0204)
sector1	-0.241***
	(0.0729)
sector2	0.137**
	(0.0437)
sector4	0.0382
	(0.0219)
sector5	0.103***
	(0.0294)

sector6	-0.155***
	(0.0234)
sector7	0.0332
	(0.0230)
sector8	0.0561
	(0.0340)
sector9	0.0142
	(0.0259)
sector10	-0.113
	(0.0858)
lninvestment	13.11
	(16.52)
lninvestment_Age	-0.00807
	(0.0102)
lninvestment_lntanassets	1.104*
	(0.461)
Age_lntanassets	-0.0000528
	(0.0000651)
lninvestment_	-0.990

sq	
	(0.610)
Age_sq	-7.67e-09
	(0.00000202)
lntanassets_sq	0.0174***
	(0.00103)
_cons	36.96
	(133.3)
NL	
STATE1	0.0000324
	(0.00399)
STATE2	0.0654***
	(0.0179)
bh	3.070*
	(1.242)
bhsq	-0.159
	(0.110)
bp	49.01*
	(19.07)
bpsq	84.38
	(56.36)
bph	-11.46**
	(4.126)

bcons				-6.174	
				(3.379)	
N					
probit				39499***	
				(284.8)	
partlin				40896***	
				(283.7)	
nl				31160***	
				(291.9)	
N	46746	46746	54462	49060	46746
R^2	0.841	0.272	0.258		
adj. R^2	0.841	0.119	0.126		

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix C: Complete regression table – East German states

	(1) lnaddedvalue	(2) lnaddedvalue	(3) lnaddedvalue	(4)	(5) lnaddedvalue
main					
lnnemployees	0.629***	0.428***	0.585***	0.540***	0.622***
	(0.00482)	(0.0131)	(0.0165)	(0.0217)	(0.0135)
lntanassets	0.174***	0.0900***	0.0515***	0.201**	0.127***
	(0.00325)	(0.00747)	(0.0105)	(0.0711)	(0.0383)
region1	0.0371*	0	0	-0.00432	
	(0.0145)	(.)	(.)	(0.0379)	
region2	0.00214	0	0	-0.0456	
	(0.0163)	(.)	(.)	(0.0408)	
region3	0.0215	0	0	0.00484	
	(0.0129)	(.)	(.)	(0.0250)	
region4	0.0211	0	0	0.00353	
	(0.0144)	(.)	(.)	(0.0284)	
sector1	-0.317***	0	0	-0.397***	
	(0.0304)	(.)	(.)	(0.0523)	
sector2	0.245***	0	0	0.314***	
	(0.0246)	(.)	(.)	(0.0744)	
sector4	0.0302	0	0	0.0157	
	(0.0180)	(.)	(.)	(0.0468)	

sector5	0.338***	0	0	0.158***
	(0.0185)	(.)	(.)	(0.0473)
sector6	-0.186***	0	0	-0.170**
	(0.0199)	(.)	(.)	(0.0609)
sector7	0.203***	0	0	0.0741
	(0.0219)	(.)	(.)	(0.0587)
sector8	0.281***	0	0	0.157*
	(0.0228)	(.)	(.)	(0.0677)
sector9	0.212***	0	0	0.125*
	(0.0197)	(.)	(.)	(0.0611)
sector10	0.386***	0	0	0.579**
	(0.0959)	(.)	(.)	(0.216)
lnmaterialcosts	0.119***	0.155***		0.114***
	(0.00302)	(0.00627)		(0.0122)
age	0.000658*	0.0211***		-0.00263
	(0.000293)	(0.00140)		(0.00817)
2011.year		0	0	
		(.)	(.)	
2012.year		-0.0232*	-0.00435	
		(0.0103)	(0.0102)	
2013.year		-0.0141	0.0261*	

		(0.00990)	(0.0102)	
2014.year		-0.0153	0.0448***	
		(0.0100)	(0.0104)	
2015.year		-0.0103	0.0657***	
		(0.00983)	(0.0103)	
2016.year		-0.00155	0.102***	
		(0.00962)	(0.0101)	
2017.year		0.000447	0.124***	
		(0.00981)	(0.00994)	
2018.year		-0.00547	0.142***	
		(0.0101)	(0.00991)	
2019.year		-0.0114	0.163***	
		(0.0107)	(0.0100)	
2020.year		0	0.189***	
		(.)	(0.0119)	
k			0.0108***	
			(0.00151)	
_cons	3.246***	4.231***	5.478***	
	(0.0324)	(0.0908)	(0.0702)	
PROBIT				
L.lninvestment				16.98
				(25.74)

L.age	-0.00366 (0.0316)
L.lntanassets	-14.46 (21.85)
L.lninvestment_age	-0.00209 (0.00481)
L.lninvestment_lntanassets	-1.910 (2.911)
L.age_lntanassets	0.00204 (0.00748)
L.lninvestment_sq	-0.0922 (0.142)
L.age_sq	0.0000225 (0.0000363)
L.lntanassets_sq	1.903 (2.899)
L.region1	0.0447 (0.0803)

L.region2	0.0574
	(0.0817)
L.region3	0.0607
	(0.0683)
L.region4	-0.0565
	(0.0902)
L.sector1	-0.147
	(0.107)
L.sector2	-0.119
	(0.192)
L.sector4	-0.0600
	(0.0776)
L.sector5	-0.297***
	(0.0854)
L.sector6	-0.0917
	(0.0760)
L.sector7	-0.0352
	(0.0912)
L.sector8	-0.0942
	(0.0809)
L.sector9	-0.0244

	(0.0739)
L.sector10	-0.00947
	(0.187)
_cons	-17.81
	(26.19)
PARTLIN	
age	0.00570
	(0.0132)
lntanassets	-4.403
	(7.326)
lnnemployees	0.540***
	(0.0217)
lnmaterialcosts	0.114***
	(0.0122)
region1	-0.00432
	(0.0379)
region2	-0.0456
	(0.0408)
region3	0.00484
	(0.0250)
region4	0.00353
	(0.0284)

sector1	-0.397***
	(0.0523)
sector2	0.314***
	(0.0744)
sector4	0.0157
	(0.0468)
sector5	0.158***
	(0.0473)
sector6	-0.170**
	(0.0609)
sector7	0.0741
	(0.0587)
sector8	0.157*
	(0.0677)
sector9	0.125*
	(0.0611)
sector10	0.579**
	(0.216)
lninvestment	5.246
	(8.407)
lninvestment_	0.000252

age	
	(0.00123)
lninvestment_lntanassets	-0.602
	(0.956)
age_lntanassets	-0.000446
	(0.00231)
lninvestment_sq	-0.0237
	(0.0417)
age_sq	-0.0000116
	(0.0000108)
lntanassets_sq	0.608
	(0.956)
_cons	-1.484
	(7.455)
NL	
STATE1	-0.00263
	(0.00817)
STATE2	0.201**
	(0.0711)
bh	1.870
	(1.365)

bhsq				-0.113	
				(0.222)	
bp				0.739	
				(13.08)	
bpsq				-1.325	
				(7.445)	
bph				-0.0477	
				(3.695)	
bcons				-1.678	
				(2.399)	
N					
probit				8236***	
				(97.44)	
partlin				8631***	
				(112.4)	
nl				6867***	
				(112.4)	
N	12886	12886	15176	9933	12886
R^2	0.857	0.282	0.265		
adj. R^2	0.857	0.129	0.134		

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix D: Calculation of Kmenta elasticity estimator

We take the formula as presented by Kmenta (1967), with a new coefficient $\hat{\beta}_3$, that adds to the Cobb-Douglas traditional function, the elasticity of substitution through a traditional panel OLS regression:

$$logX_i = log\gamma + \nu\delta logK_i + \nu(1-\delta)logL_i - 1/2\rho\nu\delta(1-\delta)][logK_i - logL_i]^2 + \mu_i$$
$$log\hat{X}_i = \hat{\beta}_0 + \hat{\beta}_1 logK_i + \hat{\beta}_2 logL_i + \hat{\beta}_3[logK_i - logL_i]^2$$

$$\hat{\beta}_0 = log\gamma,$$
$$\hat{\beta}_1 = \nu\delta$$
$$\hat{\beta}_2 = \nu(1-\delta)$$
$$\hat{\beta}_3 = -1/2\rho\nu\delta(1-\delta)$$

By working on these equations, we get the following equality for elasticity of substitution (σ), using the OLS coefficients:

$$\rho = \frac{-2\hat{\beta}_3(\hat{\beta}_1 + \hat{\beta}_2)}{\hat{\beta}_1 * \hat{\beta}_2}$$

$$\sigma = \frac{1}{1-\rho} = \frac{1}{1 - \frac{-2\hat{\beta}_3(\hat{\beta}_1 + \hat{\beta}_2)}{\hat{\beta}_1 * \hat{\beta}_2}}$$

We develop these calculations with the coefficients for West and East German States:

	West German States	East German States
$\hat{\beta}_1$ (regr. estimator, capital)	0.0400***	0.0515***
$\hat{\beta}_2$ (regr. estimator, labour)	0.495***	0.585***
$\hat{\beta}_3$ (regr. estimator, k)	0.154***	0.0108***

These estimators give us the following results:

West: 0.10727056
East: 0.686652581

To calculate this, we developed a simple calculator of Kmenta on Microsoft Excel, it can be accessed here.