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DISCUSSION PAPER

The Final Frontier? Border Effects and German Regional Wages

**Steven Brakman
Harry Garretsen
Marc Schramm**

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**Steven Brakman
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Head: Dr. Konrad Lammers

Hamburgisches Welt-Wirtschafts-Archiv (HWWA)
Hamburg Institute of International Economics
Öffentlichkeitsarbeit
Neuer Jungfernstieg 21 - 20347 Hamburg
Telefon: 040/428 34 355
Telefax: 040/428 34 451
E-mail: hwwa@hwwa.de
Internet: <http://www.hwwa.de/>

Steven Brakman
University of Groningen
Department of Economics
P.O. Box 800, 9700 AV Groningen, Netherlands
Phone : +31 50 363 3746
Fax : +31 50 363 7337
E-mail: s.brakman@eco.rug.nl

Harry Garretsen
Utrecht University
Utrecht School of Economics
Vredenburg 138
3511 Utrecht, the Netherlands
E-mail: h.garretsen@econ.uu.nl

Marc Schramm
University of Nijmegen
Centrum voor Duitsland-Studies
Huize Heyendaal, Geert Grooteplein 9
Postbus 9103, 6500 HD Nijmegen, Netherlands
Phone: 024-3611137
Fax: 024-3613006
E-mail: m.schramm@cds.kun.nl

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Abstract

Recent studies of border effects have focused on the intra-country and inter-country comparison of trade flows. It is found that borders have a negative impact on the size of cross-border trade. In order to estimate border effects on a regional level one needs not only data on inter-country but also on intra-country trade. For many countries (regional) data on intra-country trade are simply lacking, which makes an analysis of border effects and border regions cumbersome. In this paper we take a different approach to measure the impact of borders. We estimate a market potential function for German regional wages and by analysing whether German border regions can be distinguished from the other regions in terms of their wages. We use a market potential function because its basic idea (regional wages fall the further one moves away from economic centers) can be grounded on different trade theories and also because the resulting wage equation is related to border effect studies based on trade flows. We use a data set for 441 German districts for the years 1992 and 1995. In general, we find some evidence that is consistent with the existence of border effects but this evidence is probably better looked upon as an indication of a strong localisation of demand spillovers on regional wages in general. Even though border effects can not be ruled out, the overriding outcome is that of a strong localization of demand spill-overs for all German regions.

JEL classification: R10, R12, R23

Keywords: economic geography, empirical estimation, Germany

1 INTRODUCTION

Do national borders matter? From an administrative or political perspective the answer is no doubt affirmative and also from a sociological perspective few would doubt the role these borders play in for instance defining national identity. But what about the relevance of national borders from an economic perspective? Does ever-increasing economic integration make national borders irrelevant in the end or is it still useful, even in the case of the EU, to look at national borders as symbols of incomplete economic integration? In recent years numerous studies have found that national borders do indeed still matter from an economic perspective. These studies have mainly used data on cross-country trade flows and national prices differences to establish this finding. The lack of data often precludes a systematic analysis of border effects. Especially the lack of inter-regional trade flow data is responsible that a comparison between intra- and inter country trade flows often cannot be made.

The goal of this paper is to analyse for the case of Germany whether or not border effects are likely to be important and in doing so we have to circumvent the data limitation problem. As will be explained below, we will take German regional wages to be our central variable of interest. In a nutshell, we are interested in two questions. First, are wages in German border regions different from those in the other regions in Germany and second, can such a difference be attributed to a border effect? To investigate these two central questions we use a market potential function because its basic idea (regional wages fall the further one moves away from economic centers) can be grounded on different trade theories and also because the resulting wage equation is indirectly linked to border effect studies based on trade flows. We use a data set for 441 German districts for the years 1992 and 1995. The reason to use 2 years is *inter alia* to be able to say something about the possible short-term impact of “Europe 1992” or the German reunification on the distribution of regional wages.

This paper is organised as follows. In the next section we will briefly discuss the market potential approach and explain why this approach can be used to investigate border effects. Section 3 introduces our data set and deals with some estimation issues. Section 4 provides the basic (cross-section) estimation results. We find confirmation for the idea of a spatial wage structure and our results also indicate that there may be a border effect to the extent that the wages of German border regions do not seem to be influenced by demand coming from neighbouring foreign regions/countries. On the other hand, our

estimation results also indicate a strong localization of demand linkages for all German regions, regional wages in general are only mildly affected by the demand coming from other regions, these demand effects rapidly diminish as the distance between regions increases. In section 5 we estimate a number of alternative specifications of the market potential function for German regional wages, inter alia by conducting an experiment in which we assume the Netherlands to be integrated at the same level with German regions as the *Bundesland* NordrheinWestfalen and by looking at the “border” between the former FRG and GDR. Using a more structural approach we will also briefly deal in section 5 with the implications of our estimations for the trade flows between Germany and its main trading partners. Section 6 concludes.

2 THE MARKET POTENTIAL FUNCTION, WAGES AND BORDER EFFECTS

The market potential function provides an indication of the general proximity of a region to total demand or purchasing power. The “market potential” of a region decreases the further away this region is from the demand for its goods. Following the seminal study by *Harris* (1954) numerous economic geographers and regional economists have found confirmation for the idea that proximity to demand increases the market potential of a region or country. In the context of the EU, *Keeble, Owens and Thompson* (1982) is a good example of the application of the market potential approach. The market potential function is part of a more general approach which stipulates that economic interaction between objects of interest (here, regions) is a function of the economic size of these objects weighted by their distance. In international economics the so-called gravity equation of international trade is a good example of this approach. The basic notion of this approach stems from Newtonian physics and this is why it is sometimes referred to as social physics in the literature (*Krugman*, 1995).

Though convincing from an empirical point of view, the original market potential (MP) function and gravity equation lack a theoretical foundation (see also the survey by *Niebuhr and Stiller*, 2002). With respect to the market potential function it often remains unclear what “market potential” is meant to represent. Recently, however, it has turned out to be possible to give a theoretical foundation for the market potential function. In particular the new economic geography (NEG) literature is relevant here. Paul Krugman already observed (*Krugman*, 1995) that the equilibrium wage equation that is central to

the core NEG model closely resembles the market potential function as developed by *Harris* (1954), but with nominal wages as the variable representing market potential instead of trade (as shown by *Hanson*, 1998). Such a wage equation states that wages in a region are higher, the nearer this region is to regions with a high demand for its goods. A simple market potential function for regional wages, as given by equation (1) below (in logs), can therefore be looked upon as a reduced form of the equilibrium wage equation in the NEG models:

$$(1) \quad \log(W_r) = c_1 \log \left[\sum_s Y_s e^{-c_2 D_{rs}} \right] + \text{constant}$$

where W_r = nominal wages in region r , Y_s = income or GDP in region s , D_{rs} = distance between regions r and s ; c_1 and c_2 are coefficients to be estimated.

Equation (1) simply states that regional wages fall the further one moves away from economic centers (regions with a high income or GDP). This is the basic equation for our estimations. There are a number of reasons to stick to equation (1) instead of trying to estimate the underlying structural wage equation. First, to estimate the latter more data are needed and these are not readily available for Germany. Second, the MP-function is not outperformed by more structural approaches (*Brakman, Garretsen, and Schramm*, 2000, 2002 and *Roos*, 2001). Finally, the goal of the present paper is not to test the relevance of a particular model or theory, we want to use a specification that captures the notion of a spatial wage structure in a very general sense. A MP-function such as equation (1) meets this requirement and in addition it has been shown that, apart from the NEG models, the market potential function encompasses a wide range of theoretical approaches (*Harrigan*, 2001). This suits our purposes because the estimation of the market potential function for German regional wages is a means to an end, the end being the analysis of border effects.

This last observation raises the question as to why one would want to use a MP-function to test for border effects to start with. In international economics, border effects have mainly been studied in recent years by using (and comparing) inter-country and intra-country trade flows and goods prices. With complete economic integration, that is to say in the absence of a border effect, one expects that there are no significant differences between intra-country and inter-country trade flows or price movements. Or, in the case of the best-researched example, one expects, taking the role of distance into account, that trade flows and movements in goods prices between the USA and Canada behave in a similar way as the corresponding flows and prices within the USA, that is to say bet-

ween US regions. Even though there is some discussion about the precise magnitude of the border effect, studies for the case of the USA and Canada find strong confirmation for the existence of a border effect (*Engel and Rogers, 1996; McCallum, 1995; Head and Ries, 2001*). In a way these and related studies find evidence for the hypothesis that if 2 regions are 100 km. apart the degree of economic interaction is less if these countries are situated in different countries than if they are part of the same country. It is clear that this finding has implications for border *regions*: trade in these regions is truncated by the border.

Equation (1) provides us with a proxy for the degree of economic interaction: the economic size of regions corrected for distance between regions. We are particularly interested in the question whether or not regional wages in German border regions are different from wages in non-border regions. If German border regions are economically fully integrated with foreign neighbouring regions (that is, on the same par as the integration with their German neighbouring regions) we expect the MP-function to be less suited for these border regions because the demand stemming from these foreign regions is neglected in our estimations. So, we are basically interested in the question whether the MP-function is misspecified for German border regions.

Our choice to look at wages for the German case instead of regional trade flows or goods prices is also motivated by data availability (or the lack thereof in the case of for instance regional prices, or inter-regional trade) but in our view the MP-function (1) in its own right provides an interesting alternative to analyse border effects, see *Niebuhr and Stiller (2002)* for a similar observation.¹ In addition, in the context of the NEG literature it can be shown that a wage equation like equation (1) or, more accurately, its structural equivalent provides can also give us an indirect estimate of trade flows between regions. We will return to this issue at the end of our paper in section 5.3. Here, we merely note that based on *national* trade data, *Head and Mayer (2000)* find for the EU countries the border effect to be highly significant.

¹ Data on intra-country trade are scarce for EU countries but there are a few country studies that make use of inter-regional trade data. *Combes, Lafourcade, and Mayer (2002)* use data on bilateral trade flows between 94 French regions and find that regional borders matter significantly in France. Their findings are similar to those of *Wolf (2000)* for the USA and imply that border matter also matter within countries. *Nitsch (2002)* uses data on intra-German trade, that is trade between the *Bundesländer* of the former FRG and GDR, and also finds a significant border effect. On the national level data on intra-national trade for country *i* can be constructed by taking total output from country *i* minus the total exports from country *i* to the rest of the world (see for instance *Chen, 2002*) for this procedure for 7 EU countries). In our case this procedure will not do because we are interested in (border) regions and not in countries as a whole.

3 DATA

Before we turn to the estimation results a few words on the construction of our data set are in order. Germany is administratively divided into about 441 districts (*Kreise*). Of these districts a total of 119 districts are so called city-districts (*kreisfreie Stadt*), in which the district corresponds with a city. We have wage data for both 1992 and 1995 on (at most) 378 districts and 5 *Bundesländer* (Rheinland-Pfalz, Schleswig-Holstein, and the 3 city-states Bremen, Hamburg and Berlin).² We used district statistics provided by the federal and state statistical offices in Germany. Regional wages are constructed using information on the wage bill and the number of hours of labor in firms with 20 or more employees in the mining and manufacturing sector. Combining these two variables gives the regional wage W_r , which is thus measured as the average hourly wage in the manufacturing and mining sector. As to our independent variables, income Y is measured as a district's personal income tax base. Other district variables that we used in (some of) our estimations are, following *Roos* (2001), the skill composition of workers and the production structure of a district. Distance or transport costs is, of course, a crucial variable in any estimation of a market potential function and here we use the geodesic distance between districts.³ Data availability and/or deliberate sub-sampling on our part imply that the actual number of observations is smaller than 378.

The estimation of an equation like equation (1) raises several estimation issues. First of all, there is the issue of the endogeneity of particular right hand side variables like Y_s . Since we have two years of observation (1992 and 1995), the time-series element of the data would allow us to estimate in first differences. So, we mainly present cross-section estimations but we have also performed estimations for the MP-function in 1st differences. With respect to the geographical unit of analysis, in our estimations the left and right hand side variables are both measured at the district level. In *Hanson* (1998, 1999) or *Roos* (2001) the latter are typically measured at a higher level of aggregation (e.g. the US state and *Bundesland* level) so as to make it less likely that a shock to district wages W_r has an impact on Y_s . On the other hand, a lower level of geographical aggregation of the data makes it less likely that location-specific shocks (via the error-term) have an impact on the independent variables. The Glejser-test revealed that heteroskedasticity is

2 The 36 districts in Rheinland-Pfalz and the 15 districts in Schleswig-Holstein had to be aggregated at the state level because we lack regional (=district) wage data for 1992 for these districts.

3 In previous work on the market potential function for Germany (*Brakman, Garretsen and Schramm*, 2000, 2002) we have used effective travel time by car as our distance variable. This variable is, however, not available for all districts in our sample of 441 districts.

a problem and we should therefore use weighted least squares (WLS)). The weights for each specification are taken from regressing the absolute residuals (from the “unweighted” NLS estimation of (1)) on the right hand side variables. Note that since heteroskedasticity could be caused by misspecification we can not use WLS in our estimations where we explicitly want to address the possible misspecification of our MP-function for border districts, in those cases we use NLS.

4 BASIC ESTIMATION RESULTS

4.1 A first look at the border

Our basis equation to be estimated in this section is equation (2) below. The only difference between the MP-function (1) and wage equation (2) is that the latter contains two dummy variables in order to take into account that wages may be systematically different (lower) in eastern German districts or in country districts (those districts that are not a *Kreisfreie Stadt*).

$$(2) \quad \log(W_r) = c_1 \log \left[\sum_{s=1}^{441} Y_s e^{-c_2 D_{rs}} \right] + c_3 D_{east} + c_4 D_{country} + \text{constant}$$

where W_r = wages in district r , Y_s = personal income in district s , D_{rs} = distance between districts r and s , D_{east} and $D_{country}$ are dummy variables for eastern-German and country districts respectively.

We first present the estimation results for 1992. The cells in Table 1 give the estimated coefficients and, between brackets, the corresponding t-statistic. The 1st column gives the results from estimating equation (2). The results give firm support for the existence of a spatial wage structure. The coefficients c_1 and c_2 have the expected positive signs and are significant. The distance coefficient c_2 is about 0.3 which is relatively high (compared to for instance a value of 0.028 found by *Roos* (2001) for his MP-estimation for 1992 for West-Germany and the coefficient of approx. 0.2 found by *Brakman, Garretsen, and Schramm*, 2000, 2002). In section 5 we will further discuss the consequences of the size of the c_2 -coefficient for border effects. The results also show that regional wages are lower in eastern German districts (c_3 is negative).

The second column gives a first glimpse of the relevance of border effects. Estimating equation (2) with a border dummy (which equals 1 if a district is a border district) results in a significant negative coefficient for this dummy suggesting that wages in border districts are *lower* than wages in the other districts. The reason could be that on average border districts are more peripheral regions. A peripheral location might stimulate circular processes of further decline of these regions. High-skilled workers might, for example, migrate to more central regions. Inter alia to see if this could be the case, the 3rd column of Table 1 includes the skill level of workers for each district (unskilled workers and skilled workers as a share of total workers).⁴ In order to control for differences in the production structure in border regions, we added 3 variables that provide some information on a district's production structure (share of workers in service, manufacturing and agricultural sector). The addition of these variables do not change the conclusions with respect to the existence of a spatial wage structure, but the border dummy becomes insignificant. It is interesting to note that there seems to be a skill premium: wages are relatively higher in districts with more skilled workers. Note that the c_2 coefficient, though still significant, is now smaller and is more in line with aforementioned previous studies for Germany.

4.2 A second look at the border

If border districts are economically integrated with local economies at the other side of the border one would expect that the estimation of eq. (2) for Germany underestimates the actual wage level in the border districts. The reason is that demand linkages with those foreign districts are ignored and hence one underestimates the “market potential” of these German regions. To address the importance of this neglect (which implies that eq. (2) would be misspecified for border regions) we devised the following estimation strategy. We construct a hypothetical (smaller) Germany with the border regions skipped from our sample: the new “border” shifts inwards. This core of Germany includes all those districts that are at least 75 km away from the nearest border district (about 50% of the non-border districts meets this requirement). Note, that this criterion also excludes districts that do not necessarily have a foreign border, but are relatively near to a foreign country. We then estimate the MP-function (specified as in column 3 of Table

4 Skilled workers are those workers with a college degree (Fachhochschule), unskilled are those with no such degree or any on the job training.

Table 1: Basic estimation results, 1992

	Equation (2)	Eq. (2) with border dummy	Skills + prod. Structure	Sub-sample I 151 districts	Sub-sample II, 151 distr.
c₁	0.155 (13.018)	0.152 (12.943)	0.068 (5.560)	0.105 (3.757)	0.104 (3.734)
c₂	0.316 (4.235)	0.364 (3.329)	0.087 (3.503)	0.088 (3.395)	0.098 (3.415)
c₃	-0.452 (-21.322)	-0.461 (-21.800)	-0.808 (-19.386)	-0.739 (-10.671)	-0.727 (-10.334)
c₄	-0.154 (-7.645)	-0.149 (-7.393)	0.011 (0.566)	-0.019 (-0.572)	-0.021 (-0.643)
Constant	1.590 (8.742)	1.637 (9.099)	2.549 (14.141)	1.847 (4.876)	1.812 (4.601)
Border dummy		-0.053 (-3.071)	-0.017 (-0.912)	---	---
Unskilled			-0.739 (-2.944)	-0.896 (-1.687)	-0.757 (-1.447)
Skilled			4.650 (9.719)	3.363 (5.311)	3.455 (5.518)
Service sector			0.503 (2.071)	0.670 (1.656)	0.677 (1.669)
Manuf. Sector			0.253 (1.806)	0.482 (1.951)	0.531 (2.190)
Agric. Sector			-0.522 (-1.708)	0.021 (0.042)	0.123 (0.240)
Adj. R²	0.99	0.99	0.98	0.91	0.90

First three columns: Number of obs. 365, estimation method WLS, all estimations also include a dummy for the district of Erlangen in Bavaria. Fourth and fifth column: Number of obs. 151, estimation method NLS, all estimations include the Erlangen dummy.

1) for the districts that are more than 75 kilometers away from the nearest border district. This procedure gives us a sub-sample of 151 districts. For these 151 districts we again estimate the wage equation (2) using the specification as described in column 3 of

Table 1. The 4th and 5th columns of Table 1 summarise the estimation results. The difference between columns 4 and 5 is that in the specification shown by column 4 we still included the demand from districts across the newly defined border (so the personal income of border districts and districts within the 75 km. range is included in Y_s), whereas in the 5th column we estimated the MP-function for these 151 districts *as if* these 151 districts constitute a closed economy, so without dealing with demand (income) from the other districts. The coefficients estimated in the 4th column give us "true" estimates for the MP-coefficients c_1 and c_2 in equation (2), in the sense that all relevant demand for the market potential of the 151 districts is included. Column 5 is thus expected to give biased estimates of the MP-coefficients because here we neglect the demand coming from German districts that are not part of the group of 151 districts. So, the bias in column 5 is of the same nature as in columns 1 and 2.

The second step in our estimation strategy consists of comparing the *actual* wages in the 60 border districts and the other 172 districts that do not belong to the inner circle of 151 German districts, to the computed wages based on coefficients of column 4 (based on the subset of 151 regions). Given the basic idea behind the MP-function one expects that actual wage levels *outside* these 151 districts are higher than the computed wages, due to the neglect of income in foreign regions. The disregard of foreign income is assumed not to matter for the 151 districts (these districts are simply too far away from the border for foreign income to determine their market potential) and for these inner circle of German districts we assume that MP-function is not misspecified. For the remaining districts and especially for the 60 actual border districts, this is not necessarily the case because here the neglect of foreign demand may seriously underestimate the market potential and hence the corresponding district wages. This difference between actual and computed wages is expected to be the largest for the actual border districts. One also expects that the difference between actual and computed wage levels for border districts is larger if the border region "borders on" a foreign region with a relatively high income.

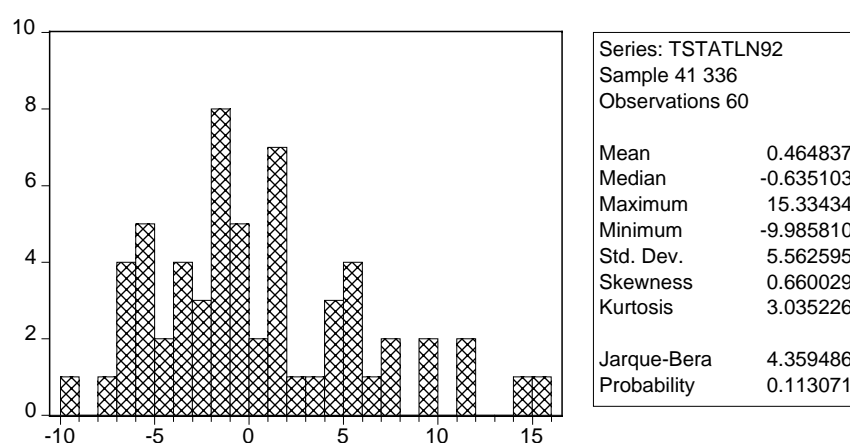
From Table 1 we can see that for both sub-sample estimations the idea of a spatial wage structure is confirmed and that the conclusions with respect to the various explanatory variables are rather similar to those that follow from the corresponding full-sample estimation in column 3 of Table 1. The estimation results for the sub-sample estimations for the 151 districts are thus subsequently used for a comparison of the actual 1992 wages for border districts as well as for districts within the 75 km. range with the compu-

ted district wages based on our sub-sample of 151 districts. To give a benchmark for this comparison we calculated the following statistic for each district concerned:

$$(actual\ wage\ level - computed\ wage\ level) / standard\ deviation\ fitted$$

In our sample there are 60 real border districts and 172 non-border districts that lie within the 75 km. range. Based on the estimation results for sub-sample I (column 4 Table 1) we find for the group of border districts as a whole that the median of the difference between the actual and computed wage level is *negative* which is not what one expects if the MP-function is thought to determine regional wage differences across space. Figure 1 gives the corresponding graph (y-axis: number of districts; x-axis: value for the test-statistic). At the same time Figure 1 shows that the distribution has a long right tail (skewness>0) which thus indicates that there are more relatively large positive deviations of the actual from the computed wages than negative ones.⁵ A similar conclusion holds for those districts that lie within the 75 km. range of a border district (not shown here). A closer look at the comparison between actual and computed wage levels for *individual* border districts reveals that the actual wages are (almost invariably) higher than the computed ones in districts at the border with Austria, Switzerland and France and actual wages are lower than the computed wages for districts that border the Czech Republic (these conclusions for individual districts also hold for 1995, see below).

Figure 1: Underestimation of actual wages for border districts, 1992



⁵ The Jarque-Bera statistic is 4.35 for the 60 border districts and this implies that we can not reject that Figure 1 displays a normal distribution (this also holds for Figure 2 below). For the actual estimation of the MP-function the Jarque Bera statistic is 2.98 which also implies a normal distribution.

If the neglect of demand or purchasing power coming from abroad does not seem to matter for wages in border districts this may be taken as indirect evidence for the existence of a border effect. Indirect, because our simple MP-function for regional wages does not enable us to say much about the possible reasons for a border effect. It might be that the degree of economic integration is still imperfect between Germany and its neighbouring countries but in the absence of formal barriers to cross-border transactions, the existence of mental borders might be relevant. In this case, economic agents impose borders on themselves, for instance because they strongly identify with “their” region and are inclined to stick to the home region for economic transactions (Van Houtum, 1998). The possible relevance of mental borders or mental distance is interesting because it would imply that border effects may not only be found between but also within countries. Indeed, the study by Combes et al. (2002) for France shows that regional border effects exist and that they are relatively strong if the social and business networks between regions are weak. The estimation results for 1992 in Table 1 support this idea because they indicate a rather strong localization of demand linkages for all German regions. In particular the estimated value for the distance coefficient c_2 indicates that demand (Y) linkages are geographically rather limited and this finding is not confined to border regions. Across the whole of Germany it is the case that a shock in Y in region r will only have an impact on wages in regions that are very close to this region.⁶

Further indirect evidence about the strong localization of demand comes from the estimation results based on sub-sample II (column 5 in Table 1). The results are very similar to those for sub-sample I and here too a comparison of actual wage levels of the “border” districts with the computed wage levels (based on the estimated coefficients for the 151 districts) did *not* confirm the idea that the actual wages in border districts are higher than the computed wages for these districts.⁷ This seems surprising because the

6 Given the strong spatial localization of demand spillovers and hence the importance of income the own region for wages, we checked whether the results with respect to the market potential function would still hold if we included in all specifications for the wage equation, as shown by Tables 1 and 2, an additional explanatory variable: income per capita of region r . This variable is a proxy for the agglomeration or income density of region r (see also Ciccone, 2002). As expected income per capita in region r has a significant positive impact on the wages in region r , but both the c_1 and c_2 coefficient remain significant thereby vindicating the basic idea of the market potential function (the distance coefficient c_2 typically increased in this extended specification which is what one would expect if a own region variable (here income per capita) is added as an additional variable to explain regional wages).

7 Note that in the estimation of sub-sample II the phrase border district does not (as opposed to sub-sample I) refer to an actual border district but instead to those German districts that border on the 151 districts that make the core of Germany.

results based on sub-sample II are biased to the extent that the income of other German districts is not allowed to influence the wages of the 151 districts, but as Table 1 shows the estimated coefficients for sub-samples I and II are almost identical which suggests that the demand coming from the German districts outside the core 151 districts is not important in determining the wages for the 151 districts. This finding is also consistent with the notion of *regional* border effects and we will return to this issue in section 5.1. But before we do this, Table 2 gives the estimation results for 1995.

For the sake of comparison and to check the “robustness” of our findings, Table 2 is a copy of Table 1 except for the fact that now the estimations are thus based on wage and income data for 1995. In general, the estimation results for the 2 years are rather similar. This is true for the two core coefficients for our MP-function, c_1 and c_2 , although for 1995 the significance of the distance coefficient is somewhat less clear-cut as for 1992. The border dummy, on the other hand seems more important in the case of 1995 (again, compare column 3 in both Tables). As for 1992, we also confronted the actual wages in the border districts as well as the wages in the districts within the 75 km. range with the computed wages based on sub-sample I. Again, we find that the actual wages are not higher than the computed wages. Figure 3 shows the results of this comparison for the 60 border districts in 1995. Again also, the median for this group of districts is negative even though the distribution is skewed (but considerably less so than for 1992), indicating a few large positive deviations from the computed wages, see Figure 2 (but, as with Figure 1, the Jarque-Bera coefficient is 1.31 which means that we can not reject that we are dealing with a normal distribution, this (not surprisingly) also holds for the actual estimation for 1995 the 151 districts (Jarque Bera statistic: 0.77)).

Figure 2: Underestimation of actual wages for border districts, 1995

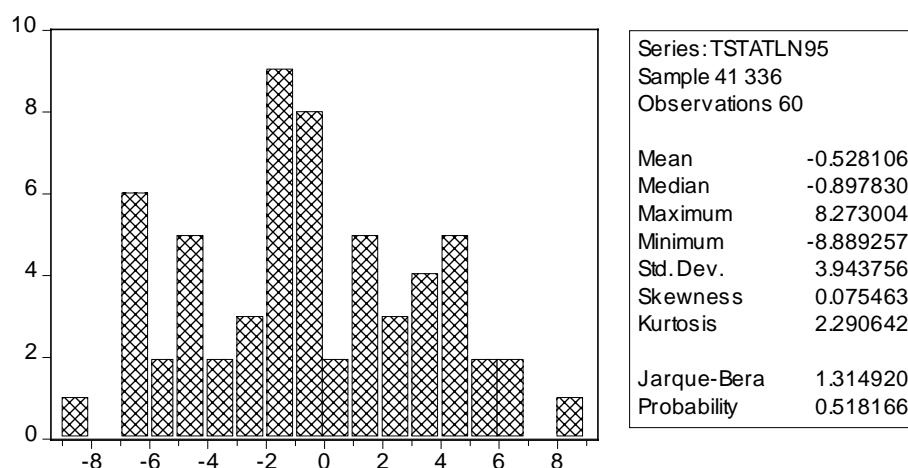


Table 2: Basic estimation results, 1995

	Equation (2)	Eq. (2) with border dummy	Skills + prod. Structure	Sub-sample I 151 districts	Sub-sample II, 151 distr.
c₁	0.168 (13.084)	0.155 (12.311)	0.051 (3.765)	0.052 (3.455)	0.108 (3.669)
c₂	0.325 (3.285)	0.534 (1.344)	0.089 (2.484)	0.175 (1.836)	0.096 (3.337)
c₃	-0.352 (-18.006)	-0.342 (-18.282)	-0.687 (-15.982)	-0.693 (-15.068)	-0.534 (-7.567)
c₄	-0.232 (-11.982)	-0.219 (-11.925)	-0.021 (-1.011)	-0.029 (-1.157)	-0.062 (-1.763)
Constant	1.603 (8.341)	1.802 (9.575)	2.626 (12.763)	2.594 (11.648)	1.754 (4.180)
Border dummy		-0.080 (-6.152)	-0.0376 (-1.878)	---	---
Unskilled			-0.679 (-2.470)	-0.624 (-1.976)	-0.423 (-0.779)
Skilled			5.141 (10.930)	4.986 (11.481)	4.003 (6.143)
Service sector			1.075 (3.929)	1.105 (4.227)	0.998 (2.359)
Manuf. Sector			0.543 (3.433)	0.591 (3.712)	0.534 (2.112)
Agric. Sector			0.263 (0.950)	-0.0203 (0.058)	0.0052 (0.0098)
Adj. R²	0.99	0.99	0.98	0.84	0.88

First three columns: Number of obs. 365, estimation method WLS, all estimations also include a dummy for the district of Erlangen in Bavaria. Fourth and fifth column: Number of obs. 151, estimation method NLS, all estimations include the Erlangen dummy.

Overall the estimation results for 1995 confirm that 1) there is a spatial wage structure in Germany and 2) wages in border districts seem not be influenced by our neglect of foreign regions in our estimations, this suggests the presence of a border effect. Also, there are no major changes when comparing 1992 and 1995. At the same time, our estimation results indicate that this “border” effect may apply between German regions as well and that it above all reflects the strong localisation of demand linkages between districts.⁸ This last finding is interesting because studies like *Head and Mayer (2000)* who, based exclusively on *national* data, conclude that a border effect exists between the EU countries may miss the point to the extent that this effect is not confined to national borders but may also be found within countries. [Appendix A](#) provides additional information on the localization of demand linkages for the case of Germany.

5 ALTERNATIVE SPECIFICATIONS

Based on the estimation results as shown in Tables 1 and 2, we analyse three issues in this section. The first issue concerns the possibility that the “border” effect does not only apply to German border districts but is above all the outcome of the fact economic interactions may be geographically limited between German districts, irrespective whether or not they are border districts (section 5.1). Next, the idea that “borders” can also be relevant within a country is analysed using the border between the former FRG and GDR as an example (section 5.2). Finally, we use a different specification for the wage equation (a wage equation based on a well-known new economic geography model) in order to be able to say something about the implicit trade flows that arise from our estimations. A comparison of these computed trade flows with actual trade flows between Germany and the Netherlands gives additional information about the presence of a border effect. In doing so, we have come full-circle because this estimation of trade flows shows that our approach can be linked the more standard border effect studies based on trade flows that we discussed in section 2 of our paper.

8 Even though the cross-section estimations for 1992 and 1995 provide support for the existence of a spatial wage structure in Germany, this is not the case when our market potential function for regional wages (2) is estimated in 1st differences using the following specification:

$$\log(W_r)_{1995} - \log(W_r)_{1992} = \text{constant} + c_1 \log\left(\sum_{s=1}^{441} [e^{-c_2 D_{rs}} Y_s]\right)_{1995} - c_1 \log\left(\sum_{s=1}^{441} [e^{-c_2 D_{rs}} Y_s]\right)_{1992} + c_3 D_{east} + \dots$$

In particular, the c_2 coefficient is insignificant. Roos (2001, pp. 183-184) reaches a similar conclusion after estimating a MP-function for western Germany in 1st differences using data for 1992 and 1996.

5.1 What if the Netherlands is replaced by Nordrhein Westfalen?

The conclusion, see section 4, that the purchasing power or demand coming from neighbouring foreign regions/countries does not seem to have an impact on the wages of German border districts can be taken as evidence in favour of a border effect. At the same time, this conclusion might simply be due to the fact that we find the demand linkages to be geographically very limited for all German districts. Only the purchasing power of districts that are very close seems to matter for a district's wage. The crucial coefficient in this respect is c_2 which can be interpreted as a spatial discount factor. We find c_2 to be about 0.08 (see column 3 in tables 1 and 2) which implies that the Y from a district that is 50 km. (100 km.) apart from the district r only has a weight of 0.02 (0.0005) in the term $\sum_{s=1}^{441} Y_s e^{-c_2 D_{rs}}$ in the MP-function. In other words, W_r is above all influenced by the “market potential” of district r itself.

In order to disentangle the border effect from the more general finding that demand from neighbouring districts (foreign or German) has a small impact on wages in border districts at any rate, we performed the following simulation experiment. Suppose that economy of the Netherlands was fully integrated with the economy of Germany to the effect that the Netherlands was a *Bundesland* of Germany and there was no cross-country border whatsoever. To simulate this we replaced the Netherlands on the map by the *Bundesland* Nordrhein Westfalen (NRW, which in terms of land-area, population and income is very similar to the Netherlands). The eastern part of NRW was geographically placed so that it replaces the eastern part of the Netherlands and “borders” German districts, the western part of NRW (which includes the Ruhrgebiet) substitutes for the western part of the Netherlands (which includes the main Dutch cities). Given that the border no longer exists, one expects regional wages in German border districts along the German-Dutch border to benefit from the replacement of the Netherlands by NRW on the map. At the same time, given the localisation of demand spillovers this effect is probably (at best) very limited.

Based on the estimated parameters as shown in column 3 of Tables 1 and 2, we effectively checked whether the additional purchasing power coming from NRW and its districts would imply higher wages in Germany. As can be learned from Table 3 the answer must be that the effect on regional wages is rather small. In our view this means

that the impact of the demand coming from other regions on W_r is geographically limited irrespective whether or not region r is a border region. This is not to say that border effects are irrelevant but only that in our market potential approach these effects are swamped by the strong localisation of demand linkages. A value for the c_2 -coefficient of around 0.08 simply means a relatively high(?) spatial discount factor in the market potential term $\sum_{s=1}^{441} Y_s e^{-c_2 D_{rs}}$ in equation (2). In this case the replacement of the purchasing

power from the economic center in the western part of the Netherlands by the purchasing power from the Ruhrgebiet-area does not make much of a difference for the German regional wages in the districts along the German-Dutch border because the weight of this purchasing power in the market potential function is negligible, see also Figure A1 in the Appendix A.⁹

Table 3 gives for 1992 for the relevant German border districts the wage differential between the simulated wages from our NRW-experiment and the estimated wages based on the outcomes for MP-function as shown by column 3 of Table 2. The 10 German districts are denoted by a *, Table 3 first lists the results for those German districts (7 in total) that are more affected by the increase in purchasing power coming from “abroad” than any border district. Note that even though these 7 districts are not border districts they are all quite close to the Dutch-German border (f.i. within the 75 km range used above).

9 A similar conclusion with respect to the limited geographical reach of (changes in) income Y for Germany can be found in *Roos*, 2001, p. 185-186 and *Brakman, Garretsen and Schramm*, 2000, Table 4. In the former study a 10% income increase in Frankfurt has only a significant impact on regional wages in regions that are very close to Frankfurt, whereas in the latter study the same result is found in an experiment where the income of Essen is increased by 10%.

Table 3: Nordrhein Westfalen instead of the Netherlands as Neighbour, 1992

Name of German district:	Wage change (in %):
Aurich	1.085
Wilhelmshaven	0.620
Oberhausen	0.471
Cloppenburg	0.149
Münster	0.021
Rhien-Sieg	0.015
Osnabrück	0.015
Kleve *	0.013
Aachen (Kreis) *	0.009
Bentheim *	0.003
Emden *	0.002
Emsland *	0.001
Heinsberg *	0.001
Leer *	0.0006
Borken *	0.0005
Aachen (Stadt) *	0.0005
Viersen *	0.0004

* denotes a border district

5.2 The former border between eastern and western Germany

Given the strong localisation of demand and our conclusion that this drives our conclusions for all German districts, we now take a closer look at the relevance of the border between the former Federal Republic of Germany and the German Democratic Republic. Is it the case that in 1992 and 1995 the former border still had an impact on the spatial wages structure and is it (still) better to consider these two economies to be separate economies? To analyse this we first estimated equation (3):

$$(3) \quad \log(W_r)_t = \text{constant} + c_1 \log \left(\sum_{s=1}^{441} \left[e^{-\{c_2 + c_3 \varphi_{rs}\} D_{rs}} Y_s \right] \right)_t + c_4 D_{\text{country districts}} + \dots$$

where $\phi_{rs} = 0$, if $r = \text{eastern (western) german district}$ and $s = \text{eastern (western) german district}$; $\phi_{rs} = 1$, if $r = \text{eastern (western) german district}$ and $s = \text{western (eastern) german district}$.

The specification is almost the same as those shown for 1992 and 1995 in column 3 of respectively Tables 1 and 2. The only difference is the c_5 -coefficient in (3) which is meant to capture the idea that, just a few years into the re-unification process, the border still exist to the extent that the (perceived) distance between a eastern and western district is typically larger than the distance between two western or eastern districts. If this is true we expect the c_5 coefficient to be significantly positive.¹⁰ It turned out, however, that this coefficient was not significantly different from zero.

We then simultaneously estimated two market potential functions, one for the 328 western districts and one for the 113 eastern districts, assuming that both economies are closed in the sense that the income variable Y in the MP-function for wages of eastern (western) districts includes eastern (western) districts only. The estimation results (not shown here) are very similar to those shown in Tables 1 and 2 for Germany as whole, and this also holds for the insignificance of the border dummy. The only notable difference is that by considering the two parts of Germany separately (in terms of not allowing western (eastern) income to influence eastern (western) wages), that the distance coefficient c_2 becomes smaller. This suggests that the localisation of demand spill-overs is somewhat weaker within the two Germanies compared to Germany as a whole. In this respect the former border still matters.

Finally, to further illustrate the idea of localised demand linkages we assumed that eastern and western German districts have their “own” economic centers: only the proximity to eastern (western) centers matters. We estimated a simple alternative for the MP-function in which 3 large German cities (Leipzig, Hamburg and Munich) were superimposed as 3 economic centers and wages only depend on a region’s own income and not on the income of other regions (this replaces the $\sum_s Y_s e^{-c_2 D_{rs}}$ term from the MP-function). Also included (but not shown in Table 4 below) for each region as independent variables were the share of high skilled workers, the area (in km^2), the distance to the nearest border region and a constant. Table 4 gives the estimation results for 1992

¹⁰ The estimation results (based on WLS) for the other coefficients for 1992 and 1995 are very similar to those reported in column 3 of Tables 1 and 2. In previous work and using a sample that consisted only of the 114 city-districts we found that c_5 was significant but had the wrong (negative) sign (Brakman, Garretsen, van Marrewijk, 2001, pp. 160-162).

and 1995 for eastern and western German districts with regional wages as the dependent variable and the distance from the 3 cities as our independent variables of interest here. Note that (with one exception) for western (eastern) German districts fall (rise) the further one moves away from Hamburg or Munich and that the opposite conclusion holds with respect to Leipzig! Again, this suggests that “borders” may also arise within countries due to the localized effects of agglomeration on regional wages.

Table 4: Western and eastern regional wages and distance from 3 main cities

	Western Germany, 1992	Western Germany, 1995	Eastern Germany, 1992	Eastern Germany, 1995
Leipzig distance	0.0011 (9.221)	0.0009 (6.653)	-0.002 (-11.457)	-0.001 (-7.150)
Hamburg distance	-0.0004 (-2.632)	-0.0007 (-4.279)	0.001 (4.632)	0.0005 (-1.958)
Munich distance	-0.0006 (-4.073)	-0.0008 (-5.637)	0.002 (9.187)	0.0009 (4.768)

Dependent variable: regional wage; # of obs.: 274 for western Germany and 91 for eastern Germany; estimation method WLS; t-statistic between brackets.

5.3 The implied bilateral trade flows between Germany and 28 countries

As we noted before, market potential functions can be derived from structural economic models. The equilibrium wage equation that is central to the core new economic geography (NEG) model closely resembles the market potential function. *Hanson* (1998, 1999) introduces a specific variant of the core NEG model that can be tested empirically. Once the structural parameters of this model are estimated we can use these estimates to derive the implied (equilibrium) regional trade flows. Data on actual inter-regional trade flows are lacking, so basically, the only way to get inter-regional trade flows is to somehow approximate trade flows between regions.

The trick we use in this section is to use parameter estimates from the wage equation of the Hanson model, and then calculate the implied inter-regional trade flows within Germany but also from Germany to other countries. By summing the exports of all

German regions to a specific region or country we can derive (equilibrium values of) total exports to that region or country. Treating, for example, the Netherlands as if it were a integrated part of the German economy, we can derive total exports to the Netherlands as if it had been completely integrated with Germany. Comparing this figure with the actual exports of Germany to the Netherlands gives us an indication of a border effect between the two countries. If border effects are relevant we expect the computed total exports to be larger than actual exports. The basic reason for this expectation is that, as will become clear below, we assume that for the foreign countries the same degree of economic integration (that is, the same set of parameters) applies as between German districts.

The equilibrium conditions in Hanson's model (five in total) are rather similar to the core NEG model, in particular the equilibrium wage equation, which is central to the empirical analysis, is identical to the (normalized) equilibrium wage equation in Krugman (1991)¹¹ and, more importantly for our present purposes, resembles the basic notion of the MP-function (1):

$$(4) \quad W_r = \left[\sum_s Y_s I_s^{\varepsilon-1} T^{D_{rs}(1-\varepsilon)} \right]^{1/\varepsilon}$$

In equation (4) W_r is the region's r (nominal) wage rate, Y is income, I is the price index for manufactured goods, ε is the elasticity of substitution for tradable (manufactured) goods. T is the transport cost parameter, and $T_{rs} = T^{D_{rs}}$, where D_{rs} is the distance between locations r and s . Transport costs T are defined as the number of manufactured goods that have to be shipped in order to ensure that one unit arrives over one unit of distance. Given the elasticity of substitution ε , it can directly be seen from equation (4) that, as with the MP-function, for every region wages are higher when demand in surrounding markets (Y_s) is higher (including its own market), when access to those markets is better (lower transport costs T). Also regional wages are higher when there is less competition for the varieties the region wants to sell in those markets (this is the extent of competition effect, measured by the price index I_s).

Ideally, one would like to directly estimate equation (4) but this is not possible mainly because the price index is an endogenous variable and the equilibrium values for I depend on wages as explanatory variable. Furthermore, empirical short-cuts are not pos-

¹¹ See for an extensive description of this model and estimation issues, *Brakman, Garretsen and Schramm* (2002), *New Economic Geography in Germany: Testing the Helpman-Hanson Model*, HWWA discussion paper, No. 172, Hamburg.

sible because data on regional price indices I are lacking. By making use of the 3 remaining equilibrium conditions in the Hanson model (not shown here), however, one can arrive at a revised version of equation (4) and this equation has been estimated for our data set of German districts. The wage equation that is actually estimated includes the three central structural parameters of the core NEG model, namely the substitution elasticity, ϵ the transport costs, T , and the share of income spent on manufactures δ (which is not part of wage equation (4), due to the specifics of the Helpman-Hanson model).¹² This estimation gave for instance for the following values for the 3 structural parameters of the model for Germany (see *Brakman, Garretsen, and Schramm, 2002*) for a detailed discussion of these results):

δ	0.58
ϵ	3.82
T	1.0078

Once we have estimated these structural parameters we can retrace our steps that led to equation (4), in order to arrive at an equation that gives us the implied trade flows associated with equation (4). Equation (4) is derived from the well-known Dixit-Stiglitz model of monopolistic competition. The idea behind the equation is simple. Once we know the break-even level of production for a producer of tradable goods (from the zero-profit condition), we can equate this break-even production level to the total demand. Total demand is derived for each firm by summing over all regions of destination. This allows us to determine what the price (and given mark-up pricing, also what the wage rate) of a variety should be, in order to sell exactly the break-even amount. The total break-even sales (that is summing over all firms) of a region r equals:

$$(5) \quad x_r = \sum_{s=1}^R \left[\left(\frac{\epsilon}{\epsilon-1} \frac{W_r T^{D_{rs}}}{I_s} \right)^{-\epsilon} T^{D_{rs}} \delta \frac{Y_s}{I_s} \right]$$

Given the parameter estimates we also know from this expression what each region r sells to, say, region h . By calculating $E_h = \sum_r x_{rh}$, we arrive at an expression for total

exports, E_h , from all regions to h . Assuming, for example, that this region is the

¹² Even though the wage equation (4) resembles the MP-function there are important differences like the way in which distance is modelled. In the MP-function the role of distance is approximated by a power law ($e^{-c_2 D_{rs}}$) whereas this is not the case in wage equation (4). This means that our estimation results for the MP-function and notably the results for the distance coefficient c_2 do not imply a particular value for the transport cost parameter T in wage equation (4).

Netherlands, we have an estimate of German exports to the Netherlands, as if the Netherlands were totally integrated into Germany. Or, in terms of our model parameters, we assume that these parameters also apply between Germany and its main trading partners.

For illustrative purposes only, we used equation (5) to calculate the implied exports from the German districts to a group of 28 countries (this group includes Germany's main trading partners). That is to say, we combined our data on German districts with ILO-data on (manufacturing) wages and income for these 28 countries and we used the location of the capital of each country to come up with the distance to German districts. To measure the price index I we took the equilibrium condition for the price index in order to get a proxy for this index for all our German districts and also for the 28 countries.¹³ It is beyond the purpose of the present paper to discuss in detail all steps to arrive at the implied exports from each German district to other German districts and the 28 countries so Table 5 just gives the implied exports from all German districts taken together to the top-10 export markets, that is to say to the countries which according to our model parameters constitute Germany's main export markets.

Table 5: Implied manufacturing exports from German districts, top-10 countries

Country	Implied exports (billions of DM)
Netherlands	17.46
Belgium	16.44
Luxembourg	8.82
Switzerland	7.70
Denmark	2.74
Austria	0.97
France	0.53
Czech Rep.	0.42
UK	0.028
Slovenia	0.016

13 This equilibrium condition is $I_r = \left[\sum_s \lambda_s (T^{D_{rs}})^{1-\varepsilon} W_s^{1-\varepsilon} \right]^{1/(1-\varepsilon)}$ where λ is share of region or country r in total (manufacturing) labor force.

The results in Table 5 are (too put it mildly) surprising and they imply a severe *underestimation* of the actual exports from Germany. The flip side of this observation is that our calculations show that for each German district the demand for its goods predominantly comes from the district itself and from districts in the immediate vicinity. This is nothing but a reminder of the fact that localisation of demand linkages is quite strong according to our estimations. In terms of a border effect, the results in Table 5 are at odds with such an effect because for a border effect to be present, it should be the case that our implied trade flows (based on the notion that the 28 countries are integrated on the same par with German district r as any other German district) are larger than the actual trade flows.

To give an idea as to how far the implied exports are underestimating the actual exports: France is Germany's main export market and the actual total exports are about 100 times as large as the (manufacturing) exports implied by Table 5, whereas the implied manufacturing exports to its 2nd export market, the USA, are zero! At the same time exports to for instance Luxembourg are overestimated.¹⁴ A main factor behind these "remarkable" results is the fact that of all the 28 countries concerned the capital of Luxembourg is the by far the closest to the German border. At the district level, we see that for each and every German district the export to the foreign countries is seriously underestimated. At the same time, since demand equals supply for each district, our calculations show that for most German districts the demand for its goods comes from the district itself.

6 CONCLUSIONS

In this paper we have used a market potential function for German regional wages to analyse border effects. The main reason to use a market potential function is that it provides a tool for the analysis of the degree of economic interaction between regions and in principle could provide an answer to the question whether regional wages in German border regions are different from wages in the other regions. In addition, a market po-

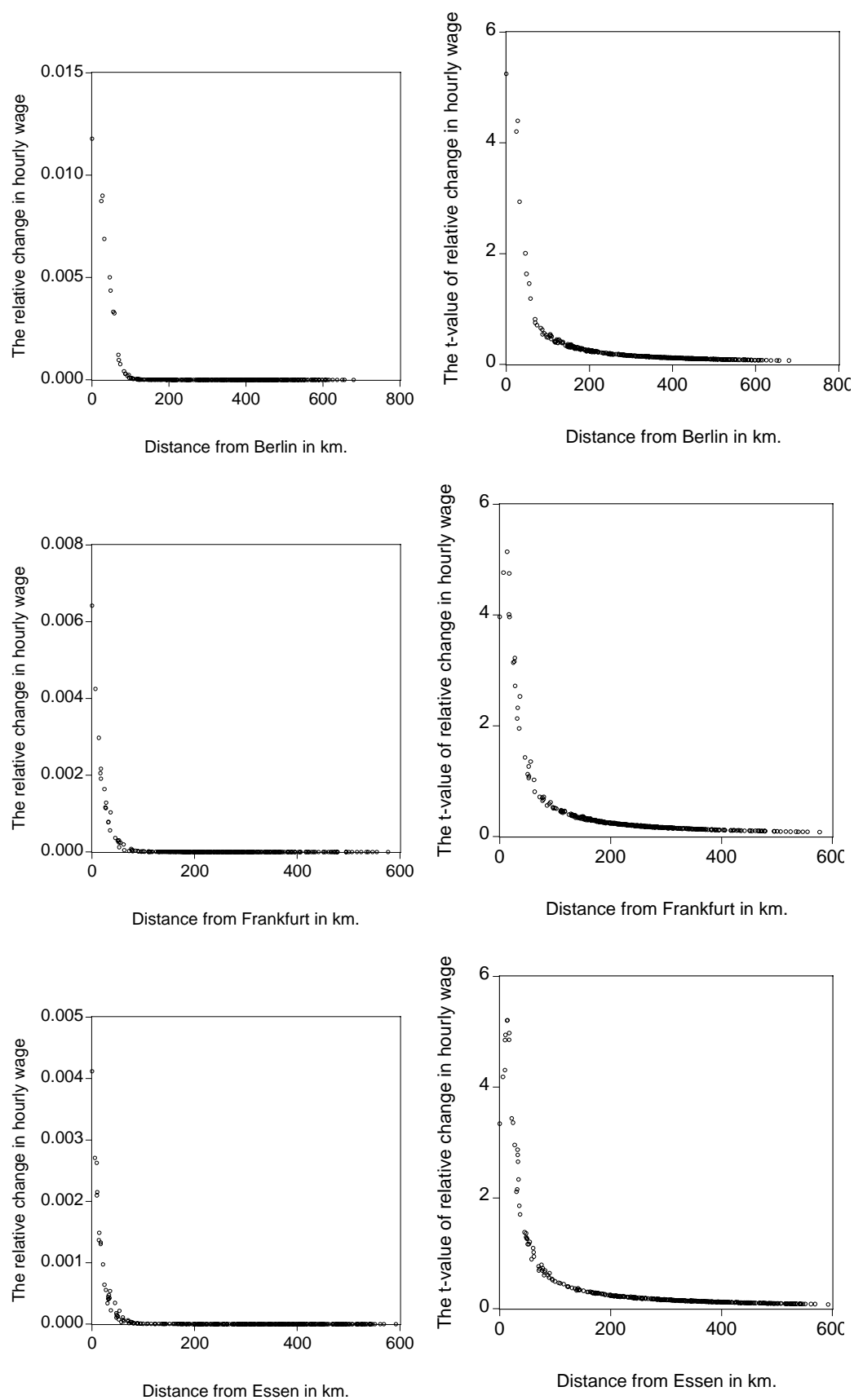
¹⁴ Different values for ε , δ or $\log(T)$ produce somewhat different results but inevitably in all our calculations the actual exports are underestimated by a wide margin. *Brakman, Garretsen, and van Marrewijk* (2001, pp. 12-13) estimate a gravity equation for German international trade and they also find that German trade decreases with distance but the distance effect is nowhere as strong as Table 5 suggests. In terms of actual exports the top-5 trading partners in the mid 1990s (billions of DM) were France (120), USA (102), UK (93), Italy (80), and the Netherlands (76).

tential function can be grounded upon various trade theories and, certainly also relevant for the German case, it is relatively easy to estimate in terms of data requirements. A few results stand out. First, we find confirmation for a spatial wage structure which confirms the relevance of a market potential function. Second, in our estimations we neglect the impact of demand or purchasing power stemming abroad but this neglect seems to have no bearing on the wages in border regions which suggests the existence of a border effect. Third, notwithstanding the previous conclusion, it turns out that demand spillovers are geographically rather limited between German regions as well and this fact seems to account for the alleged border effect in our approach. Fourth, additional estimations confirm the strong localisation of demand linkages on regional wages and the border effect is hence better described as being a manifestation of the more general finding that the impact of demand from neighbouring regions on a region's wages falls quickly when distance between regions increases. Finally, even though the market potential function *a priori* is an interesting instrument to analyse border effects our empirical results suggest that a more structural approach is called for. Notwithstanding our first results we think that the use of a structural wage equation to simulate regional trade flows points to a fruitful avenue for future research.

Appendix: A Localization of demand linkages: an experiment

To once more bring across what is driving our results, the strong localisation of demand linkages, we conducted the following experiment (see also *Roos*, 2001 and *Brakman et al.*, 2000) that also allows us to visualise the central point of our analysis. We increased the personal income tax base in subsequently Berlin, Essen, and Frankfurt by 10% for the year 1992 and investigated what this would have meant for the wages in other German districts in 1992. To make sure that our results would not be influenced by the neglect of foreign income we conducted the experiment for the sub-sample of 151 districts that make up the “core” of Germany and we hence based our experiment on the coefficients as shown in column IV of table 2. Figure A1 gives the results of this experiment for respectively the 10% income increase in Berlin, Frankfurt and Essen. In each case the left- panel gives for each districts the relative wage change due to the positive income shock and the distance from the source of the income shock. The right-panel does the same but now the t-value of the relative wage change on the vertical axis. Figure A1 above all shows that distance matters and also that in each of the 3 cases the relative wage changes are always rather small and only significant (t-value exceeding 2) in a few cases.

Figure A1: Wages after a 10% Income Increase in Berlin/Frankfurt/Essen



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