Time zones matter: The impact of distance and timezones on services trade *

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Abstract

Using distance and time zone differences as a measure for coordination costs between service suppliers and consumers, we employ a Hausman-Taylor model for services trade through foreign affiliates. Given the need for proximity in the provision of services, factors like distance place a higher cost burden on the provision of services. In addition, differences in time zones add significantly to the cost of doing business abroad. By decomposing the impact of distance into a longitudinal and latitudinal component and accounting for differences in time zones, we can identify in detail the factors driving the impact of increasing coordination costs on the delivery of services through foreign affiliates. Working with a bilateral U.S. data set on foreign affiliate sales in services we examine the impact of time zone differences and East-West and North-South distance on U.S. outward affiliate sales. We find that both distance as well as time zone differences have a consistent positive and significant effect on foreign affiliate sales. By decomposing the effect of distance our results show that increasing East-West or North-South distance by 100 kilometers raises affiliates sales by 2%. Finally, focusing on time zone differences our findings suggest that affiliate sales increase the more time zones we have to overcome.

Keywords: Foreign Affiliates Trade, International Trade in Services, Coordination Costs, Time zones
JEL codes: F14, F21, F23, L80

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1 Introduction

Given that services are a flow and not a stock, direct proximity and interaction between supplier and consumer are more important for trade in services than for trade in goods. From a historical viewpoint, this has hampered growth in international services trade relative to commodities trade. However, due to technical change, the proximity burden has progressively weakened in recent decades for some (but not all) service activities (Christen and Francois, 2010). This has evoked a dramatic growth in services trade and foreign investment and has led to a nascent empirical and theoretical literature on trade in services (Francois and Hoekman, 2010). However, the non-storable nature of services may still imply a double coincidence in both time and space of the proximity between the provider and the consumer (Kikuchi and Marjit, 2010). This means that factors like distance place an additional cost burden on some aspects of service provision. Additionally, time zone differences add significantly to the cost of doing business abroad. In this paper, we disentangle the impact of distance from longitudinal and latitudinal distance as well as time zone differences on services trade through foreign affiliates using a panel of U.S. affiliate sales. Our data on affiliate sales allows more sector detail than found in the recent literature, which relies instead on FDI as a proxy for affiliate sales. We show that time zone differences as well as latitudinal and longitudinal distance in particular are major drivers for U.S. outward affiliates sales.

Questions raised in the recent literature on services trade and investment are closely related to the large body of empirical evidence regarding determinants of multinational activity with respect to goods production and trade. But the data issues are even more severe for services investment than for goods, placing even more constraints on the scope for empirical analysis of services trade and FDI linkages. Indeed, because of data issues the recent literature along these lines uses FDI flows or stocks as a proxy for affiliate sales. For example, Grünfeld and Moxnes (2003) explore the determinants of services trade and foreign affiliate sales using FDI stocks as a proxy for foreign affiliate sales in a gravity model. They find that trade barriers and distance have a strong negative impact on exports and FDI, while GDP and similar income levels have a significant positive impact. Kolstad and Villanger (2008) study the determinants of service FDI with panel analysis for the whole service sector and a small number of subsectors. They conclude that FDI in services tends to be more market seeking and find strong correlation between manufacturing FDI and FDI in producer services as well as an important impact of institutional quality and democracy

on services FDI. Furthermore, a recent study by Christen and Francois (2010) suggests that the overall response of individual service firms aggregated by industries to distance leads to a striking difference in the impact of distance on the mix of affiliate sales and direct cross-border exports when comparing goods and services. The authors' findings show that at the industry level, the importance of proximity between supplier and consumer appears empirically robust in explaining increased affiliate activity relative to cross-border sales with increased distance. They show that multinational activity in services increases relative to direct exports the further away are host countries, the lower are investment barriers and the higher is manufacturing FDI, while common language familiarities and bigger markets foster affiliate activity additionally.

To summarize, recent literature on trade in services highlighted the role of distance as a cost burden and further transactions costs that may affect the cost of doing business. In particular, empirical literature based on the gravity models of bilateral trade distinguished between two sets of variables to account for transactions costs. The first group of variables is based on geographical characteristics across countries and country pairs, such as distance, contiguity, or whether one or both countries in the pair are landlocked and mainly capture costs directly linked to transportation costs. The second group comprises variables related to cultural and historical ties between countries, such as common language, past colonial links and similar cultural heritages and take into account further transaction costs that may affect the cost of doing business abroad. However, none of these variables precisely capture transactions costs due to the need of real time interaction between providers and buyers like it is the case for trade in services. Of course, recent developments in telecommunication, like e-mail and teleconference communication, contributed to reduce costs of transaction and facilitated (real time) communication. Since those technical improvements are in a broader sense substitutable with face-to-face interaction North-South distances can be overcome more easily. However, differences in time zones can matter and can not be neglected in terms of transaction costs. Time zone differences are present in real time communication as well as in travel and increasing East-West distance can have major negative impacts on both. Regarding real time communication, time zone differences between two countries impedes communication and may lead in the extreme case to no overlap in business working hours. With respect to traveling, East-West distance is more severe since a jet lag may affect the productivity of business travelers. Interactions between provider and user in real time are especially relevant for information intensive services that require a high degree of interaction in real

time. Frequent real time communication is in particular important between headquarters and their foreign affiliates, thus looking at foreign affiliate sales seems to be a good approach to us to examine the effects of time zone differences, and in particular differences in longitudinal and latitudinal distance.

So far little attention has be paid to the impact of time zones on economic outcomes. There exist few papers that address the determinants of bilateral equity flows and returns. Kamstra et al. (2000) study the effect of changes due to daylight saving time on equity returns and their results show that returns are significantly lower after daylight saving time changes. Portes and Rey (2005) examine the impact of bilateral distance on bilateral equity flows and the authors find a significantly negative effect of distance which can be interpreted in terms of informational cost between local and foreign investors. Furthermore the results support that overlapping stock market trading hours, a variable that accounts in some sense for time zone differences, have a significant positive effect on equity flows. Given these findings increased coordination costs due to time zone differences should have an important impact on foreign affiliate sales. In a similar paper Loungani et al. (2002) extend the work by Portes and Rey (2005) to the case of bilateral FDI flows. Their results show that trade as well as investment flows rises as "transactional distance" is reduced. Hattari and Rajan (2008) examine the role of distance and time zone differences on FDI flows to developing Asia using bilateral FDI flows over the period 1990 to 2005. Their results suggest that physical distance is partly captured by the effect of time zone differences and that time zone differences appear to hamper FDI flows.

In a related paper, Stein and Daude (2007) estimate the effects of time zone differences on bilateral stocks of foreign direct investment (FDI) in a cross-section analysis. They use OECD data for 17 OECD source and 58 host countries over a period from 1997 to 1999 and show that longitudinal distance in the form of time zone differences impose important transaction costs between parties. Besides using time zone differences to account for transaction costs, they authors also decompose the distance between a country pair into a longitudinal and latitudinal component. Their findings show that differences in time zones have a significantly negative impact on the location of FDI. Moreover, both components of distance (North-South and East-West) are significant and have a negative impact on bilateral FDI stocks. However, the impact of longitudinal distance is significantly larger than the latitudinal measure. In an extension the authors study the importance of time zone differences as a determinant of bilat-

eral trade and their findings suggest that differences in time zones also matter for trade, but the impact is much smaller than compared to the one found for FDI. For robustness checks the authors also apply alternative measures of time zone differences, such as minimum time zone differences to account for countries with multiple time zones and overlapping business hours, similar to the variable - overlap in trading hours - used by Portes and Rey (2005).

We proceed in this paper as follows. In Section 2, we describe the data set and the explain in detail the decomposition of distance into a longitudinal and latitudinal component. The subsequent Section 3 discusses the empirical strategy and presents the results. We offer a brief summary and concluding remarks in Section 4.

2 Data and the decomposition of distance

In order to examine the effects of time zone differences on the location of foreign direct investment, we use outward affiliates sales data from the United States. These detailed data on U.S. direct investment abroad is drawn from the Benchmark Surveys conducted by the Bureau of Economic Analysis (BEA) which are published every five years. The benchmark surveys offer the most comprehensive dataset with respect to firms covered and disaggregation of the data. U.S. direct investment abroad comprises all foreign business enterprises which are owned at least 10 percent, directly or indirectly, by a U.S. investor. The data for foreign affiliates are disaggregated by country and industry of the affiliate or by industry of the U.S. parent. Besides the advantageous structure of the information gathered on the affiliates abroad, the surveys additionally collect data on the financial structure of the U.S. parent and their foreign affiliates as well as on balance of payments transactions between the two parties. This allows for a very precise analysis of sales of services by majority-owned foreign affiliates.[1] For our purposes we make use of the information gathered on sales of services by majority-owned foreign affiliates to foreigners in the non-bank field, disaggregated by country and industry of the affiliate. The classification by country of the affiliate defines the country in which the affiliate's physical

[1] In this surveys, data on foreign affiliates and their U.S.parents are presented for five groups - all affiliates and any combinations between bank and non-bank affiliates and parents as well as differences in ownership. In this paper, we entirely focus on majority-owned nonbank affiliates of nonbank U.S. parents. A majority-owned foreign affiliate (MOFA) is a foreign affiliate in which the combined direct and indirect ownership interest of all U.S. parents exceeds 50 percent. Data for MOFAs rather than for all foreign affiliates are relevant in order to examine the foreign investments over which U.S. parents exert unambiguous control (U.S. Bureau of Economic Analysis, 2008).

assets are located or in which its primary activity is carried out. The industry classification based on NAICS (North American Industry Classification System) was assigned on the basis of the sector accounting for the largest percentage of sales. Individual service sectors are typically characterized by a handful of large firms representing a relatively large share of the market. Thus, data points are frequently suppressed in published data because they represent the data of a single firm, and as such the data reveal confidential business information. Moreover BEA also does not report small values of affiliate sales, in detail non-zero values smaller than half a million U.S. Dollars.
Our dataset comprises information for 61 partner countries for five different service sectors - wholesale trade, information services, financial and insurance services, professional, scientific and technical services as well as the combined sector other industries. In total we gather information from four benchmark surveys covering the years 1989, 1994, 1999 and 2004. Over the time horizon affiliate sales in all service sectors across partner countries increased steadily, whereby the highest growth was in other industries followed by financial and insurance service and professional, scientific and technical services.

To identify the determinants of affiliate sales we use several explanatory variables suggested by the recent theoretical and empirical literature. The size of the partner country market is captured through GDP (measured in billions of current U.S. dollars). According to previous literature, market size is expected to have a positive impact on services trade and especially foreign affiliate sales. Additionally, to control for economic development and wealth we also include GDP per capita of the partner country. Data for GDP and population come from the World Bank's World Development Indicators (WDI). To control for openness in the service sector we use trade in services as percent of GDP, defined as the sum of service exports and imports divided by the value of GDP, all measured in current U.S. dollars. Furthermore, we also include the value added in services as percent of GDP to account for the importance of service transactions in terms of the value added content of trade. Services embodied in trade on a value added basis amounts to roughly one third of services trade and sheds light to the importance of non-tradables in trade (Francois and Manchin, 2011). Both variables are drawn from the World Bank's World Development Indicators (WDI).
To account for bilateral variables that may affect the transactions costs and the cost of doing business abroad we use a set of standard gravity variables, like distance, and dummy variables for contiguity, common language familiar-

ities, common membership in a regional trade agreement and whether one or both countries in the pair are landlocked. Geographic characteristics, together with data on cultural familiarity are taken from Mayer and Zignago (2006).[2] However, none of these variables precisely capture transactions costs due to the need of real time interaction between providers and buyers like it is the case for trade in services. In order to decompose the impact of distance (calculated following the great circle formula) we apply two different measures: time zone differences and longitudinal and latitudinal distance. To measure the relevance of time zones on affiliates sales we calculate time zone differences between the capital of the Unites States, Washington D.C. and the capital of the respective partner country. The variable varies from 0 to 12 and is based on standard time zone differences.[3] To account for the possibility of non-linear effects of time zones we generate dummy variables for each possible value of time zone difference. The basis is the zero hour difference in time zones and is captured in the constant term in the econometric model. Moreover, we also build groups of time zone differences to account for continents and geographical borders.[4] Increased time zone differences between the U.S. and the partner countries involves higher transactions costs for services trade and therefore increases the incentive for trade through affiliates. For robustness analyses we also use an alternative measure of time zone differences, overlapping office hours. This variable varies between 0 and 9, assuming a standard working time from 9am to 5pm in each country. As mentioned earlier, Portes and Rey (2005) as well as Stein and Daude (2007) use this measure and find significant positive impacts on bilateral equity flows as well as bilateral FDI stocks.

Our second measure to account for real time interaction in services is based on the approach introduced by Stein and Daude (2007), where the authors decompose the distance between the source and the host country into a longitudinal and latitudinal component. We apply their method and decompose the distance between Washington D.C. and the capital of the respective partner country into these two parts.[5] Each capital can be characterized by specific longitude and latitude gradients ($La_{Capital}, Lo_{Capital}$). We use this infor-

[2] http://www.cepii.com/anglaisgraph/bdd/distances.htm

[3] We do not account for country specific daylight saving times.

[4] The hourly difference in time zones is also characterized by leaps due to the Atlantic sea. We do not have any observation with a time zone difference of three and four hours to Washington D.C..

[5] To decompose distance into these two components we make use of the adapted Great Circle Calculator written by Ed Williams, published at the National Hurricane Center of the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, http://www.nhc.noaa.gov/gccalc.shtml

mation to define latitudinal distance - North-South distance - as great circle distance in kilometers (km) from $(La_{WashingtonD.C.}, Lo_{WashingtonD.C.})$ to $(La_{Capital}, Lo_{Capital})$ of the respective partner country, holding the longitude gradient constant at one of the two capitals. The longitudinal component defined as the East-West distance in kilometers between Washington D.C. and the capital of the host country is not that simple, since we need to account for the proximity to the equator (longer distance) or to the pole (shorter distance), depending on the particular latitude gradient we hold constant. Thus, we once held latitude constant at Washington D.C. and the other time at the capital of the partner country. Our measure of longitudinal distance is just the average of these two distances. We will further clarify this problem with an example. Assume we are interested in the longitudinal distance between Washington D.C. and Helsinki, the capital of Finland. Washington D.C. is located at $(La_{WashingtonD.C.}, Lo_{WashingtonD.C.}) = (39.92N, 77.02W)$ while Helsinki is located at $(La_{Helsinki}, Lo_{Helsinki}) = (60.15N, 25.03E)$. The longitudinal distance fixing the latitude gradient of Washington D.C. is 8136 km, while it is 5059 km fixing the latitude of Helsinki, since Helsinki is closer to the pole. Taking the average we yield an average longitudinal distance of 6597.5 km between the two capitals.

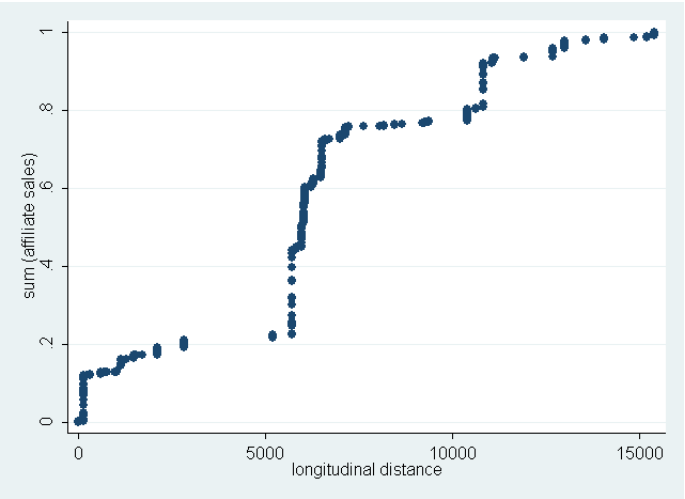
As expected, we observe a high correlation between our two measures - longitudinal and latitudinal distance, as well as time zone differences. Differences in time zones is to a great extent determined by East-West distance. Technically a time zone is defined as 15° of longitude in width, which constitutes one hour of earth's rotation relative to the sun. Solely one hourly zone in the Pacific Sea is split into two 7.5° wide zones by the 180th meridian, partly coinciding with the international date line. In general most of the time zones on land are offset in whole numbers of hours from the Universal Coordinated Time (UTC), just few are determined by 30 or 45 minutes from an adjacent time zone, like it is the case in India. While our longitudinal distance variable is to a greater extent a continuous measure of East-West distance and indirect also one of time zones, our dummy variables on differences in time zones implicitly captures some East-west distance and bundles longitudinal distance into groups. We will use this relationship between longitudinal distance and differences in time zones in our empirical model in the following Section 3.

3 Empirical strategy and results

Summary statistics for both our dependent variable as well as our explanatory variables are reported in Table 1. Sales of services by majority-owned non-

bank foreign affiliates vary between zero and 31.402 millions of U.S. dollars. The major trading partners in terms of affiliate sales are Great Britain, Japan, Canada, Bermuda, Germany, France and Taiwan. Although we observe zeros in our data it's not really a problem for our empirical analysis since it just concerns Trinidad and Tobago that does not report any affiliate sales. Their data is either suppressed (revealing the information of a single firm) or set to zero whenever affiliate sales are smaller than 500.000 U.S Dollars. While distance between the capitals following the great circle formula varies between around 737 and 16.371 kilometers our decomposed longitudinal and latitudinal components are bounded between 2 to 15.428 and 38 to 9012 kilometers. Figure 1 shows the development of affiliates sales over longitudinal distance.[6] We can observe a steadily increase of affiliate sales as we increase East-West distance, but the increase is characterized by a stepwise function, indicating that specific values of longitudinal distance have a greater impact on affiliate sales than others. More interestingly, in a range of 5.000 to 6.000 kilometers we can observe 20% to 60% of all affiliate sales, and about 80% of U.S. outward affiliate sales are in a range of 10.000 kilometers. Regarding the variable measuring time zone differences we see that the average partner country is located between five and six time zones away from the east coast of the United States. Moreover only few countries in our sample are landlocked and not surprisingly not adjacent to the United States. However, more than a quarter of our partner countries share the same language, English, as official language.

Figure 1: The development of affiliate sales over longitudinal distance



[6] We aggregated affiliates sales over all dimensions, partner countries, years and sectors

Table 1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Affiliate sales	735	1011.341	2711.454	0	31402
Log Affiliate sales	676	5.329065	2.042554	0	10.35463
Distance capitals	1016	7825.595	4021.269	737.0425	16371.12
Longitudinal distance	1016	6516	4516.826	2	15428.5
Latitudinal distance	1016	2583.14	2274.749	38	9012
Time zone differences	1016	5.621063	3.711334	0	12
Overlapping working hours	1016	3.795276	3.134021	0	9
Services value added (%GDP)	925	60.8109	11.70365	23.69907	90.85753
Trade in Services (%GDP)	938	18.59726	19.37309	2.126198	161.028
GDP	998	365803	692686.6	1501.5	4760168
GDP per capita	998	13597.97	13292.09	223.2644	74107.89
Log GDP	998	11.67979	1.652111	7.31422	15.37579
Log GDP per capita	998	8.842412	1.347682	5.408357	11.21328
Landlocked	1016	0.0728346	0.2599929	0	1
Common language	1016	0.2716535	0.4450313	0	1
Contiguity	1016	0.0354331	0.1849628	0	1
RTA	1016	0.0590551	0.2358439	0	1

Following the discussion of distance and transactions costs in previous literature, both time zone differences and the longitudinal as well as latitudinal component of distance should be important for observed affiliate sales in services. In its original formulation, the gravity model predicted bilateral trade flows as a function of distance between any two countries and their size. The approach has been widely applied in international trade literature. Recently, the original model specification (Tinbergen, 1962) has been augmented by the inclusion of additional variables which are thought to effect trade flows, such as dummy variables for language familiarities, trade barriers or historical linkages between the countries. In addition, better controls have been introduced for country-specific factors in the standard model of bilateral flows (Baldwin and Taglioni, 2006; Feenstra, 2002). Since trade flows between countries change over time, the empirical estimation of gravity models is increasingly conducted using panel data specifications which is also used in this paper. In formal terms, we use an augmented standard gravity model, which can be written as

$$lnAffiliatesales_{ijt}^{k} = \beta_0 + \beta_{\mathbf{1}}\mathbf{X_{ijt}} + \beta_{\mathbf{1}}\mathbf{X_{it}} + \beta_{\mathbf{2}}\mathbf{Z_{ij}} + \alpha_{\mathbf{t}} + \alpha_{\mathbf{k}} + \varepsilon_{ijt}^{k} + \mu_i, \quad (1)$$

where i, j, t and k index the U.S., partner countries, time and service sectors. The dependent variable $AffiliateSales_{ijt}^{k}$ represents the logarithm of U.S. outward affiliate sales between the U.S. and the partner country in a specific service

sector and year. While vector X_{ijt} comprises time-varying variables between the home and the host country, X_{it} represents time-varying explanatory variables for country i (GDP, GDP per capita, etc.) and vector Z_{ij} comprises time invariant explanatory variables for the country pair (distance, common language, etc.). The error term is composed of two error components, where μ_i is the unobservable individual effect and ε_{ijt}^k is the remainder error term. Additionally, we also include sector and time fixed effects in our estimation. As Baltagi et al. (2003) have shown, OLS and random effects estimators are substantially biased when some time-varying and time-fixed right hand side variables are correlated with the unobservable individual effects. To account for this possible endogeneity problem among the right hand side regressors we employ the Hausman-Taylor model (HTM) (Hausman and Taylor, 1981). The HTM is in principal based on an instrumental variable approach that uses information for the instruments solely from internal data transformations of the variables in the model to eliminate the correlation between the explanatory variables and the unobserved individual effects. Thus no external information for model estimation is needed and the approach abstracts from the "all or nothing" correlation among the explanatory variables and the error components that is assumed in the standard fixed and random effects models. The fixed effects model (FEM) implicitly assumes that all explanatory variables may be related to the unobserved effects and eliminates this correlation by the within transformation. In contrast, the random effects model (REM) assumes no correlation between the explanatory variables and the unobserved determinants. The HTM gets around this issue, however the approach asks to split the set of variables into two subsets with respect to the correlation to the unobserved individual effect, which is often not a trivial task. We therefore split X and Z into two sets of variables: $X = [X_1; X_2]$ and $Z = [Z_1; Z_2]$, where X_1 and Z_1 are assumed as exogenous, while X_2 and Z_2 are endogenous since they are correlated with the individual effects μ_i. The within transformation would get rid of the unobserved determinants and thus the bias, but we would also lose the time invariant vector Z_i and the within transformation will not give us estimates for β_2. We assume that the logarithm of GDP of the partner country, trade in services as percent of GDP as well as the dummy variable on common language familiarities are endogenous. Thus, let X_2= (Log GDP, Services (% of GDP)) and Z_2=(Common Language, Longitude). We also include year and sector dummies in the above specified estimation strategy. The basis for the year effects is our first benchmark survey from the year 1989, and for the different service sectors Wholesale trade is the respective reference sector. To test the appropriateness of the HTM compared

to FEM, we apply a Hausman specification test. The test statistic of 6.36 is less than the critical chi-squared value with five degrees of freedom at the 5% significance level, so the null hypothesis is not rejected and the HTM is more efficient. Testing of different specifications in previous literature, such as Egger (2005), confirm our findings that the Hausman-Taylor approach seems to be the most appropriate estimator for gravity models irrespective if we look on trade in goods or services.

In our empirical approach we make use of both our measures for distance - time zone differences as well as the latitudinal and longitudinal components of distance. To capture the different impact of each variable, we employ three different specifications that account for direct and indirect effects, as well as non-linearities of our decomposed distance measures. In our first specification we disentangle distance into a longitudinal and latitudinal component and look at the direct impact of both of these distance measures on outward affiliate sales. The results from our first specification following equation 1 using a Hausman-Taylor approach are presented in column 1 of Table 2. We find a very consistent positive impact of longitudinal and latitudinal distance on multinational activity. Our results suggest that both distance components are equally important for affiliate sales and an increase in one of the two distance measures by 100 kilometers increases affiliates sales by 2%. In addition, our findings support the importance of service transactions in terms of the value added content of trade as previous papers have highlighted. Our dummy variables capturing the geographical characteristics, like our contiguity and landlocked measures, have both the expected sign. While being adjacent to the U.S. fosters affiliates sales, being landlocked has a significant negative impact on the location of affiliates. In contrast to previous findings, our measure for cultural ties, whether to countries share the same language, seems to have a negative effect on affiliate sales. Surprisingly, our proxy for market size, GPD, is not significant at all. Our control for the economic development has a positive impact on affiliates sales and is significant at the 10% significance level. Our findings support our idea that controlling for different service sectors is a necessary task. As our results show, especially professional, scientific and technical services, as well as information services rely heavily on interaction between provider and consumer and on a local establishment. In finance and insurance services, where most of the information exchange can be handled via online services, affiliates seem to be of minor importance.

To account for differences in time zones as an alternative way to measure East-West distance we pool hourly difference in time zones into specific groups considering continents and geographical borders. In our baseline specification we comprise the hourly time zone differences into five groups, whereby the reference group are all countries with zero time zone difference to Washington D.C.. The first group summarizes all countries that are one to two time zones away from the eats coast of the U.S.. The second group comprises all countries with five to seven time zone differences, while the third group is determined by eight and nine hours differences. The last group includes all countries with a time zone difference of ten hours or more. The results from our baseline second specification using the five groups of pooled time zone difference variables are reported in column 1 of Table 3. In addition to these five groups of pooled time zone differences we use alternative thresholds to group the countries with respect to their time zone. These results are presented in in column 2 to 4 of Table 3. As we can see from our baseline model in column 1 being further away in terms of time zones raises affiliate sales compared to our reference group with no time zone difference. Across all approaches a time zone difference of 1 or 2 hours has no significant impact on affiliate sales compared to the baseline. However, crossing the Atlantic Sea and bearing a time zone difference or more than 5 hours significantly raises the need for an affiliate, although our findings suggest that there is no impact in the time zone group of 8 to 9 hours in compared to our reference group. If we consider different specification of the pooled time zones our results remain robust across the various specifications. In the most detailed analysis in column 3 of Table 3 our findings suggest that there exist special ranges in which time zone differences are more important. It seems that that we can observe three natural thresholds, 5 to 6 hours, 9 to 10.5 hours and 11 to 12 hours, which raise the cost of doing business abroad. The first group to a great extent summarizes all Western and Central European countries that are across the Atlantic sea, where interaction between providers and consumers is hampered by time zone differences and travel involves a long-distance flight. Our second group is bearing a hourly time zone difference of 9 to 10.5 hours, which means almost no overlap in business working hours and severe problems for real time communication. The last group with more than 11 hours constitutes the group with the highest distance to the United States and thus higher transaction costs enhance the level of affiliate activity in this areas. Regarding our North-South distance component the impact of latitudinal distance remains robust compared to our first specification. An increase of 100 kilometers in North-South distance raises affiliate sales by 3%. The logarithm

of GDP per capita, our control for the economic development of a country, has a significantly positive effect on affiliate sales in all estimations. Additionally, affiliate sales are driven by a higher extent of value added content of trade. Our variables controlling for other determinants that influence transactions costs again remain robust to our first specification and have the expected sign, except for the dummy on language familiarities. Our findings in Table 3 again confirm our proposition that we need to control for the nature of services, by using sector specific dummy variables. We find a significantly positive impact of the different service sectors compared to our baseline and the impact across service sectors is varying. Again the strongest impact can be found for professional, scientific an technical services.

Our second specification is in addition extended to take in account the possibility of non-linear effects of time zones by using dummy variables for every time zone difference in our data set. Using groups of time zone differences we implicitly assume that the impact of time zone differences varies across different groups of hourly differences, but is the same within the specified group. In practise this specifications assumes that for instance the impact in time zone differences across Europe is the same, independently if we operate an affiliate in Great Britain that is five hours away from the east coast of the U.S. or in Poland that involves a time zone difference of six hours. Moreover, also when we introduce dummy variables for each time zone difference we implicitly do not take into account the possible longitudinal distance between partner countries in the same time zone, like it is the case for Finland and South Africa. We address this issue in two ways. First, we include both measures longitudinal and latitudinal distance component as well as groups of time zone differences as we have done in our second specification and account for an impact of longitudinal distance within a time zone more precisely in a spline regression model that we employ in our third specification. Based on the groups of differences in time zones we specify threshold values, so-called knots, in terms of longitudinal distance. As in specification two we comprise the hourly time zone differences into five groups and define the knots as the minimal longitudinal distance in each group.

Controlling for non-linear effects of time zones by using dummy variables for every time zone difference our results support the idea that some time zones are more important compared to others. As column 2 of Table 2 shows being away one hour or two in terms of time zones does not have a significant impact

Table 2: Regression results: Distance components and time zone differences

Explanatory variables	(1)	(2)
Longitude	0.0002*	
	(0.000)	
Latitude	0.0002**	0.0003***
	(0.000)	(0.000)
Log GDP	-0.0569	0.2031
	(0.502)	(0.359)
Log GDPpc	0.7410*	0.3280
	(0.392)	(0.251)
Trade in Service	0.0121	0.0150
	(0.009)	(0.009)
Service Value added	0.0638***	0.0613***
	(0.014)	(0.012)
Landlocked	-1.9341*	-1.3170**
	(1.017)	(0.668)
Contiguity	4.4047**	4.6508***
	(1.862)	(1.677)
Language	-3.6676*	-3.2059**
	(1.928)	(1.589)
RTA	-0.0316	0.0032
	(0.321)	(0.305)
1 hour		-1.0065
		(0.662)
2 hours		-0.0165
		(1.108)
5 hours		5.6253***
		(1.967)
6 hours		1.3626
		(0.837)
7 hours		0.4068
		(0.765)
8 hours		0.1829
		(1.014)
9 hours		2.9312*
		(1.580)
10 hours		2.3480*
		(1.328)
10.5 hours		4.9703*
		(2.736)
11 hours		2.6899**
		(1.201)
12 hours		0.5068
		(0.988)
y94	-0.0658	-0.0386
	(0.152)	(0.148)
y99	0.2325	0.2707
	(0.179)	(0.174)
y04	0.3081	0.3589
	(0.238)	(0.233)
Information services	0.8966*	0.7391**
	(0.474)	(0.362)
Finance & insurance services	0.6528	0.6258*
	(0.453)	(0.349)
Professional, scientific & technical services	1.0399**	1.0848***
	(0.440)	(0.339)
Other services	0.6961	0.7571**
	(0.483)	(0.372)
Constant	-3.6676*	-3.2059**
	(1.928)	(1.589)
Observations	607	607
rho	0.867	0.806
sigma e	0.864	0.864
sigma u	2.206	1.758

Notes: Standard errors are reported in parentheses. *, ** and *** indicate statistical significance at the 10-percent level, 5-percent level, and 1-percent level.

Table 3: Regression results: Pooled time zone differences

Explanatory variables	(1)	(2)	(3)	(4)	(5)
Longitude					-0.0021*
					(0.001)
Latitude	0.0003***	0.0003**	0.0003***	0.0003***	0.0006***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log GDP	-0.1054	-0.2128	-0.0008	-0.1790	0.6073
	(0.432)	(0.461)	(0.373)	(0.455)	(0.609)
Log GDPpc	0.7360**	0.7836**	0.4661**	0.7753**	-0.2911
	(0.292)	(0.304)	(0.221)	(0.303)	(0.606)
Trade in Service	0.0123	0.0131	0.0140	0.0125	0.0144
	(0.010)	(0.010)	(0.010)	(0.010)	(0.009)
Service Value added	0.0597***	0.0607***	0.0580***	0.0597***	0.0676***
	(0.014)	(0.014)	(0.013)	(0.014)	(0.013)
Landlocked	-1.8459**	-2.0278**	-2.1155***	-1.9763**	0.3390
	(0.816)	(0.875)	(0.771)	(0.864)	(1.604)
Contiguity	4.8687***	5.2516***	4.7931***	5.1697***	4.3341**
	(1.741)	(1.855)	(1.579)	(1.843)	(2.200)
Language	-3.2129**	-3.6774**	-2.7602**	-3.4248**	1.6614
	(1.416)	(1.542)	(1.224)	(1.477)	(3.291)
RTA	-0.0104	-0.0002	0.0308	-0.0092	-0.0940
	(0.339)	(0.346)	(0.328)	(0.344)	(0.296)
1 to 2 hours	-0.3911	-0.3972	-0.4061	-0.4185	2.9495
	(0.617)	(0.642)	(0.561)	(0.633)	(2.083)
5 to 7 hours	1.7027*				17.0652**
	(0.931)				(8.203)
8 to 9 hours	1.8696				20.8242**
	(1.213)				(10.201)
10 to 12 hours	3.1180**			3.3476**	29.7285**
	(1.368)			(1.440)	(14.290)
5 to 6 hours			2.4493**		
			(0.992)		
5 to 8 hours		1.8001*			
		(0.981)			
9 to 12 hours		3.4803**			
		(1.460)			
7 to 8 hours			0.6960		
			(0.785)		
9 to 10.5 hours			3.6313**		
			(1.552)		
11 to 12 hours			2.3616**		
			(1.008)		
5 to 9 hours				1.8765*	
				(0.999)	
y94	-0.0294	-0.0100	0.0170	-0.0148	-0.0192
	(0.162)	(0.167)	(0.161)	(0.166)	(0.145)
y99	0.2707	0.3035	0.3387*	0.2932	0.2944*
	(0.188)	(0.197)	(0.190)	(0.195)	(0.175)
y04	0.3687	0.4211	0.4675*	0.4035	0.4274*
	(0.252)	(0.266)	(0.257)	(0.263)	(0.234)
Information services	0.8555**	0.8799**	0.8102**	0.8643**	0.7535
	(0.398)	(0.416)	(0.362)	(0.407)	(0.649)
Finance & insurance services	0.6640*	0.6726*	0.6031*	0.6712*	0.5195
	(0.379)	(0.396)	(0.344)	(0.388)	(0.630)
Professional, scientific & technical services	1.0562***	1.0673***	1.0681***	1.0585***	1.2133**
	(0.368)	(0.385)	(0.335)	(0.377)	(0.615)
Other services	0.7387*	0.7649*	0.7146*	0.7504*	0.9074
	(0.409)	(0.428)	(0.372)	(0.419)	(0.674)
Constant	-6.4380***	-5.7023**	-5.4638**	-6.0629**	-8.5376***
	(2.497)	(2.685)	(2.550)	(2.614)	(2.887)
Observations	607	607	607	607	607

Notes: Standard errors are reported in parentheses. *, ** and *** indicate statistical significance at the 10-percent level, 5-percent level, and 1-percent level.

on affiliates sales compared to our base group with zero hourly difference. But we find a strong positive impact of being away five hours in terms of time zones. This means that as soon as distance or the difference in time zones increases significantly, the cost burden of trade in services in terms of higher transaction costs seems to foster affiliate sales. Further, our findings show that time zone differences of nine to eleven hours significantly raise affiliate sales again compared to our reference group. Especially countries in these areas suffer from high transaction cost due to a few or no overlapping in working hours and high distances to the United States. Our maximum time zone difference of 12 hours, where we can observe only few countries in our sample, has no significant impact. Our coefficients for the other variables remain robust compared to our first specification. In addition to our first model, all service sector dummies suggest a significantly positive impact on affiliate sales in comparison to our baseline group.

To account for the varying longitudinal distance within one group of pooled time zone differences we extend our second specification by including longitudinal as well as latitudinal distance in addition to the groups of time zones from our basic specification (see column 1 of Table 3). The results are presented in column 5 of Table 3. By including latitudinal distance in addition to the pooled time zone difference the coefficient of longitudinal distance turns negative and is significantly different from zero at the 10% significance level. Increasing longitudinal distance by 100 kilometers reduces affiliate sales by 20%. However, this negative impact of East-West distance is offset by the significantly positive effect of the pooled time zones. Being away more than five hours in terms of time zone differences to the U.S. increases affiliates sales significantly compared to our reference group. Interestingly, the impact within a time zone increases steadily the more time zones we have to take into account. Reversing the interpretation of these two measures we can say that being further away in time zones significantly raises affiliate sales, although accounting for the actual East-West distance our findings suggest that adding one kilometer to the East-West distance harms affiliate sales by 0.2%. Our measure for North-South distance remains robust, although the impact of latitudinal distance increased compared to our first specification to 6% for an additional distance of 100 kilometers. With respect to our other explanatory variables the results are robust across the various specifications.

To account for an impact of longitudinal distance within a time zone more precisely we employ a spline regression model as our third specification. Based

Table 4: Regression results: Spline regression model

Explanatory variables	(1)
Longitude	-0.0011
	(0.001)
Latitude	0.0003**
	(0.000)
Log GDP	0.2881
	(0.353)
Log GDPpc	0.4042*
	(0.236)
Trade in Service	0.0113
	(0.009)
Service Value added	0.0576***
	(0.012)
Landlocked	-1.0157
	(0.663)
Contiguity	3.1588**
	(1.375)
Language	-1.3734
	(1.141)
RTA	0.0038
	(0.300)
Longitude-t_1	0.0016
	(0.002)
Longitude-t_2	-0.0008**
	(0.000)
Longitude-t_3	0.0062**
	(0.003)
Longitude-t_4	-0.0062**
	(0.003)
y94	-0.0630
	(0.146)
y99	0.2219
	(0.172)
y04	0.2769
	(0.228)
Information services	0.8105**
	(0.371)
Finance & insurance services	0.6154*
	(0.354)
Professional, scientific & technical services	1.0668***
	(0.344)
Other services	0.7021*
	(0.381)
Constant	-7.7000***
	(2.200)
Observations	607

Notes: Standard errors are reported in parentheses. *, ** and *** indicate statistical significance at the 10-percent level, 5-percent level, and 1-percent level.

on the longitudinal distance determining the groups of time zone differences (as we have specified them in our second specification) - 1to 2 hours, 5 to 7 hours, 8 to 9 hours and 10 to 12 hours - we define threshold values. To make the function piecewise continuous we require that the segments join at the knots. Table 4 reports our results from the spline regression model where we can show that the impact of longitudinal distance within a time zone is varying. Our results suggest that our measure for longitude distance in the base scenario with zero hourly differences in time zones is negative, however not significant. Increasing longitudinal distance and moving to the group of countries with 1 or 2 hours of time zone difference the impact on affiliates sales is positive, but again insignificant. Interestingly, if we move further to our group with 5 to 7 hours of time zone differences our findings show a significant negative effect. The effect is positive and significant if we increase longitudinal distance and the number of time zone differences to 8 and 9 hours and turns negative again if we exceed a time zone difference of 10 hours. Our results suggest that the impact is quite ambiguous within a group of time zones. While increasing longitudinal distance once we passed the 5 hours threshold has negative effects, the impact of increasing distance is positive for the group with an hourly difference of 8 and 9 hours. The reason for this may build upon our argument that particular distances and time zones are disadvantageous with respect to traveling and real time communication and therefore require a heavier dose of multinational activity. Regarding the results on the other explanatory variables our findings to do not change much with respect to our first specification.

Overall, our specifications allow the conclusion that the results are quite robust and the methodology used is appropriate for our research question. This leads to a discussion of possible limitations of our study. Due to data limitations for affiliate sales statistics our study is based on U.S. outward affiliate sales, where the U.S. represents the only source country. Clearly, our research design would be enriched if we could build upon bilateral foreign affiliate sales data. Nevertheless, our empirical approach tries to overcome these caveats and to incorporate a model that does account for our data issues. Future research questions in this kind of area could include the impact of distance components and time zone differences in goods trade in comparison to trade in services. Additionally, one could raise the question of how services off-shoring is determined by time zones and to what extent the advantages of time zone differences that allows for working around the clock are implemented.[7]

[7] See Kikuchi and Marjit (2010) for a theoretical discussion of this question.

4 Conclusions

In this paper we focus on the impact of distance and time zone differences on trade in services through foreign affiliates. We offer a alternative way to measure distance in terms of transactions cost. Hence, we decompose distance into a longitudinal and latitudinal component to capture East-West and North-South distance separately. Additionally, as an alternative measure we use differences in time zones to account for difficulties in real time interaction necessary for the provision of certain services. Due to the need for proximity factors like distance place an additional cost burden on some forms of service delivery. Additionally, time zone differences add significantly to the cost of doing business abroad. Both measures of transaction costs appear empirically robust in explaining increased affiliate sales. By increasing longitudinal or latitudinal distance by 100 kilometers affiliate sales increase by 2%. Our findings on increased time zone differences confirm this proximity burden. By moving further away from the Unites States in terms of time zones we find a significantly positive impact on affiliate sales for time zone differences of 5 hours and 9 or more hours. The value added content of services trade as well as the economic development of the partner countries enhance affiliates sales additionally. Due to the heterogenous nature of services our results support our proposition that we have to account for various service sectors. We find that foreign affiliates especially play a important role for information intensive services, such as professional, scientific and technical as well as information services.

References

Baldwin, R. E., Taglioni, D., 2006. Gravity for dummies and dummies for gravity equations. CEPR Discussion Paper No. 5850.

Baltagi, B., Bresson, G., Pirotte, A., 2003. Fixed effects, random effects or hausman taylor?: A pretest estimator. Economic Letters 79, 361–369.

Christen, E., Francois, J., 2010. Modes of delivery in services. CEPR Discussion Paper No. 7912.

Egger, P., 2005. Alternative techniques for estimation of cross-section gravity models. Review of International Economics 13 (5), 881–891.

Feenstra, R., 2002. Border effects and the gravity equation: Consistent methods for estimation. Scottish Journal of Political Economy 49(5), 491 – 506.

Francois, J., Manchin, M., 2011. Services linkages and the value added content of trade. Washington DC: World Bank working paper.

Francois, J. F., Hoekman, B., 2010. Services trade and policy. Journal of Economic Literature forthcoming.

Grünfeld, L. A., Moxnes, A., 2003. The intangible globalization: Explaining the patterns of international trade in services. Norwegian Institute for International Affairs. Working Paper No. 657 - 2003.

Hattari, R., Rajan, R., 2008. Sources of fdi flows to developing asia: The roles of distance and time zones. ADB Institute Working Paper No. 117.

Hausman, J., Taylor, W., 1981. Panel data and unobservable individual effects. Econometrica 49, 1377–1398.

Kamstra, M., Kramer, l., Levi, M., 2000. Losing sleep at the marklet: The daylight-savings anomaly. American Economic Review 90 (4), 1005–1011.

Kikuchi, T., Marjit, S., 2010. Time zones and periodic intra-industry trade. EERI Research Paper Series No. 08/2010.

Kolstad, I., Villanger, E., 2008. Determinats of foreign direct investment in services. European Journal of Political Economy 24, 518 – 533.

Loungani, P., Mody, A., Razin, A., 2002. The global disconnect: the role of transactional distance and scale economies in gravity equations. Scottish Journal of Political Economy 49(5), 526–543.

Mayer, T., Zignago, S., 2006. Notes on cepii's distances measures. CEPII, Paris.

Portes, R., Rey, H., 2005. The determinats of cross-border equity flows. Journal of International Economics 65, 269–296.

Stein, E., Daude, C., 2007. Longitude matters: Time zones and the location of foreign direct investment. Journal of International Economics 71, 96–112.

Tinbergen, J., 1962. Shaping the World Economy: Suggestions for an International Economic Policy. New York: Twentieth Century Fund.

U.S. Bureau of Economic Analysis, 2008. U.S. Direct Investment Abroad: 2004 Final Benchmark Data. Washington, DC: U.S. Government Printing Office, November 2008.