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Time zones matter: The impact of distance and time zones 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 by foreign affiliates. Given the need for proximity in the provision of services, factors like distance place a higher cost burden on the delivery of services in foreign markets. In addition, differences in time zones add significantly to the cost of doing business abroad. Decomposing the impact of distance into a longitudinal and latitudinal component and accounting for differences in time zones, it is possible to 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 this paper examines the impact of time zone differences and East-West and North-South distance on U.S. outward affiliate sales. Both distance as well as time zone differences have a significant positive 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 the non-storable nature of services, proximity and interaction between supplier and consumer play a more prominent role for trade in services than for trade in goods. From a historical perspective, the special characteristics of services hampered growth in international service transactions and services were seen as non-tradables for a long time. However, technical change in the last decades has increasingly weakened the proximity burden for some (but not all) service activities (Christen and Francois, 2010). As a result, services trade and foreign investment marked strong growth over the recent decade, which also led to a nascent rise in 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 service provision. Additionally, time zone differences add significantly to the cost of doing business abroad due to the double coincidence.

This paper attempts to identify the role of distance in terms of transaction costs in the delivery of services by foreign affiliates. Essentially, this paper offers an alternative way to measure geographical distance by disentangling distance into a longitudinal and latitudinal component and using time zone differences. It contributes to the literature in several ways: First, extending similar previous studies, I present empirical evidence on the impact of transaction costs on foreign affiliate sales. Working with a panel of U.S. affiliate sales the empirical analysis allows more sector detail than found in recent literature, which mostly relies as a proxy for affiliate sales on Foreign direct investment (FDI). Second, both measures of distance directly attempt to address the importance of the proximity requirement for face-to-face interaction and real time communication in services trade, which is particularly important between headquarters and their foreign affiliates. My findings show that time zone differences as well as latitudinal and longitudinal distance in particular are major drivers for U.S. outward affiliates sales.

Questions posed in the upcoming literature on trade and foreign investment in services are mainly based on the set of empirical analysis examining the determinants of multinational activity with respect to trade in goods. Regarding the availability of data for service activities, data issues are especially severe for foreign investment, narrowing the scope of empirical analysis for services

trade and investment. Indeed, because of data issues recent literature 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 sub-sectors. 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 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. The results support 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 highlights the role of distance as a cost burden and further transaction 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 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 transaction costs due to the need of real time interaction between providers and buyers like it is the case for some service activities. Of course, recent developments in telecommuni-

cation, like e-mail and teleconference communication, contributed to reducing 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. In East-West direction, 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 impede 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 examine the effects of time zone differences, and in particular differences in longitudinal and latitudinal distance.

So far little attention has been paid to the impact of time zones on economic outcomes.[1] 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 are expected to have an important impact on foreign affiliate sales. In a similar paper Loungani et al. (2002) base the analysis on the case of bilateral FDI flows. Their results show that trade as well as investment flows rise 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

[1] From a medical perspective Paulson (1996) highlights the symptoms of a jet lag on the physiologic circadian rhythm and sleep cycle. He states that symptoms of a jet lag become relevant with time zone changes of 5 hours or more. Comparing the direction of the travel, more time is needed to re-establish the circadian equilibrium when flying eastward than westwards.

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, the 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 bilateral trade and their findings suggest that differences in time zones also matter for trade, but the impact is much smaller 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).

The paper proceeds as follows. Section 2, describes the data set and explains in detail the decomposition of distance into a longitudinal and latitudinal component and the measure of time zone differences. The subsequent Section 3 discusses the empirical strategy and presents the results. Section 4, offers a brief summary and concluding remarks.

2 Data and the decomposition of distance

In order to examine the effects of time zone differences on the location of foreign direct investment, I 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 at least 10 percent, directly or indirectly, by an U.S. investor. The data for foreign affiliates are disaggregated by country and industry of the affili-

ate 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.[2] For this purpose I 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 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.
The 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 I 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, with the highest growth in other industries followed by financial and insurance service and professional, scientific and technical services.

To identify the determinants of affiliate sales I 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 I also include

[2]In these 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, I 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).

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 I 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, I 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 amount to roughly one third of services trade, which sheds light on 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 transaction costs and the cost of doing business abroad this paper uses a set of standard gravity variables, like distance, and dummy variables for contiguity, common language familiarities, 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).[3] 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) I apply two different measures: time zone differences and longitudinal and latitudinal distance. To measure the relevance of time zones on affiliates sales I 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.[4]

To account for the possibility of non-linear effects of time zones I 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, I also build groups of time zone differences to account for continents and geographical borders.[5] 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

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

[4] I do not account for country specific daylight saving times.

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

affiliates. For an alternative robustness analysis I also use overlapping office hours as a measure for time zone differences.[6] 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.

The 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. In applying their method and distance between Washington D.C. and the capital of the respective partner country is decomposed into these two distance parts.[7] Each capital can be characterized by specific longitude and latitude gradients $(La_{Capital}, Lo_{Capital})$. This information allows 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 one need to account for the proximity to the equator (longer distance) or to the pole (shorter distance), depending on the particular latitude gradient that is held constant. Thus, I once held the latitude constant at Washington D.C. and the other time at the capital of the partner country. My measure of longitudinal distance is the average of these two distances. I will further clarify this problem by giving 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 I yield an average longitudinal distance of 6597.5 km between the two capitals.

[6] Results are available upon request.

[7] To decompose distance into these two components I 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

As expected, I observe a high correlation between the 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 the earth's rotation relative to the sun. Only one hourly time 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 for instance. While the longitudinal distance variable is to a greater extent a continuous measure of East-West distance and indirect also one of the time zones, the dummy variables on differences in time zones implicitly captures some East-west distance and bundles longitudinal distance into groups. I will account for this relationship between longitudinal distance and differences in time zones in the empirical model in the following Section 3.

3 Empirical specification and estimation results

Summary statistics for both my dependent variables as well as my 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 I observe zeros in the data it's not really a problem for my 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 the distance between the capitals following the great circle formula varies between around 737 and 16.371 kilometers the decomposed longitudinal and latitudinal components are bounded between 2 to 15.428 and 38 to 9012 kilometers. Figure 1 pictures the affiliates sales, accumulated over longitudinal distance. Obviously, East-West distance plays a crucial role for the distribution of affiliate sales as 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 my sample are landlocked and not surprisingly not adjacent to

the United States. However, more than a quarter of the partner countries share the same language, English, as official language.

Figure 1: The role of East-West distance for affiliate activity

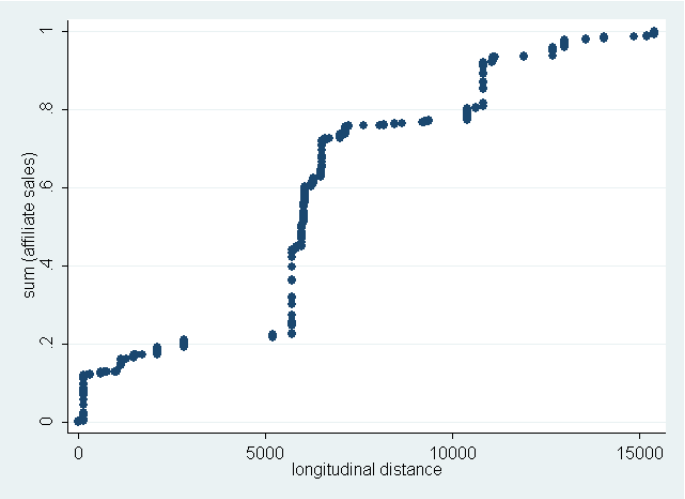

Table 1: Descriptive Statistics

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

From a theoretical point of view the decision to export or to serve the foreign market through local establishments, as addressed in this paper, is based on the proximity-concentration trade-off (Brainard, 1993, 1997; Helpman et al., 2004;

Neary, 2009). Depending on the relationship between variable trade costs and additional fixed costs of establishing a subsidiary a profit-maximizing firm will choose different modes to serve the foreign market. With respect to the model we expect that higher fixed costs favor exporting over FDI, whereas higher trade costs foster FDI over exporting. Additionally, for a comparison over space the model implies that further away markets should be served by FDI. However, empirical evidence does not support these hypotheses from theory. Empirical evidence shows that both exports and FDI fall with distance. This may implies that also fixed costs depend on distance, such that the implications from the proximity-concentration trade-off are not clear. One possible explanation for this could be that distance proxies for other factors than trade costs, such as for instance costs of communicating with foreign subsidiaries (Neary, 2009). However, in a theoretical framework with heterogenous firms (Helpman et al., 2004) distance also affects marginal costs. The implications from the export versus FDI decision with heterogenous firms show that as distance increases more firms will engage in FDI than exporting (Christen and Francois, 2010). The reason for this is a shift in the cutoff point that makes producing abroad more profitable as distance increases. This paper aims at examining the impact of distance on foreign affiliate sales by using different measures of distance that try to account for the special nature of services trade.

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 affect 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 by using panel data specifications which are also used in this paper. In formal terms, I use an augmented standard gravity model, which can be written as

$$lnAffiliatesales_{jt}^{k} = \beta_0 + \beta_1 \mathbf{X}_{jt} + \beta_2 \mathbf{Z}_j + \alpha_t + \gamma_k + \mu_j + \varepsilon_{jt}^{k}, \qquad (1)$$

where j, t and k index partner countries, time and service sectors. The dependent variable $AffiliateSales_{jt}^{k}$ represents the logarithm of outward affiliate sales of U.S. MNEs' in the partner country j in a specific service sector k and

year t. While vector X_{jt} represents importer-specific time-varying explanatory variables for country j (GDP, GDP per capita, etc.), vector Z_j comprises time invariant explanatory variables for the country j (distance, common language, etc.). The error term is composed of two error components, where μ_j is the unobservable individual host country effect and ε_{jt}^k is the remainder error term. Additionally, the estimation also includes sector and time fixed effects.

As Baltagi et al. (2003) have shown, OLS and random effects estimators are substantially biased when some the right hand side variables - either time-varying or time-invariant - are correlated with the unobservable individual effects. To account for this possible endogeneity problem among the right hand side regressors I employ a Hausman-Taylor model (HTM) (Hausman and Taylor, 1981). The HTM is 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 (Mundlak, 1978). 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 for splitting the set of variables into two subsets with respect to the correlation to the unobserved individual effect, which is often not a trivial task. In particular, X and Z are split 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_j. The within transformation would get rid of the unobserved determinants and thus the bias, but we would also lose the time invariant vector Z_j and the within transformation will not give us estimates for β_2. It's plausible to 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). I also include year and sector dummies in the above specified estimation

strategy. The basis for the year effects is the 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, I apply a Hausman specification test (Baltagi, 2008). 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. The testing of different specifications in previous literature, such as Egger (2005), confirms my findings that the Hausman-Taylor approach seems to be the most appropriate estimator for gravity models irrespective of whether we look on trade in goods or services.

The empirical approach makes use of both measures for distance - time zone differences as well as the latitudinal and longitudinal components of distance. To capture the different impact of each variable, I employ three different specifications that account for direct and indirect effects, as well as non-linearities of my decomposed distance measures. The first specification disentangles distance into a longitudinal and latitudinal component and looks at the direct impact of both of these distance measures on outward affiliate sales. The results from the first specification following equation 1 using a Hausman-Taylor approach are presented in column 1 of Table 2. I find a highly significant positive impact of longitudinal and latitudinal distance on multinational activity. The 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, my findings support the importance of service transactions in terms of the value added content of trade as previous papers have highlighted. The dummy variables capturing the geographical characteristics, like the 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, the measure for cultural ties, whether two countries share the same language, seems to have a negative effect on affiliate sales. Surprisingly, the proxy for market size, GPD, is not significant at all. The control for the economic development has a positive impact on affiliates sales and is significant at the 10% significance level. The findings support that controlling for different service sectors is necessary and relevant for the empirical analysis. As my 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. The results on the explanatory variables remain robust across all three specifications and are therefore not reported in the remaining tables. [8]

To account for differences in time zones as an alternative way to measure East-West distance the second specification pools hourly difference in time zones into specific groups considering continents and geographical borders. In the baseline estimation the hourly time zone differences are comprised 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 east coast of the U.S.. The second group comprises all countries with five to seven hourly 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 the 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 I use alternative thresholds to group the countries with respect to their time zone.

These results are presented in column 2 to 4 of Table 3. As we can see from the baseline model in column 1 being further away in terms of time zones raises affiliate sales compared to the 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 my findings suggest that there is no impact in the time zone group of 8 to 9 hours compared to the reference group. The results remain relatively robust when considering different specifications of the pooled time zones. In the most detailed analysis in column 3 of Table 3 my 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 as indicated by the positive and highly significant coefficients. The first group to a great extent summarizes all Western and Central

[8] The full table of results for all three specifications are available upon request.

European countries that do business across the Atlantic sea, where interaction between providers and consumers is hampered by time zone differences and travel involves a long-distance flight. The second group bears an hourly time zone difference of 9 to 10.5 hours, where almost no overlap in business working hours and severe problems for real time communication prevail. The last group with more than 11 hours constitutes the group with the highest distance to the United States. Hence, higher transaction costs enhance the level of affiliate activity in this areas. Regarding the North-South distance component the impact of latitudinal distance remains robust compared to my first specification. An increase of 100 kilometers in North-South distance raises affiliate sales by 3%.

The third specification is extended to take into account the possibility of non-linear effects of time zones by using dummy variables for every time zone difference in the data set. Using groups of time zone differences, I 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 these specifications assume that for instance the impact in time zone differences across Europe is the same, independently if one operates an affiliate in Great Britain that is five hours away from the east coast of the U.S. or in Poland which 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. I address this issue by including both distance measures, longitudinal and latitudinal distance components as well as groups of time zone differences.

Controlling for non-linear effects of time zones by using dummy variables for every time zone difference the 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 on affiliates sales compared to the base group with zero hourly difference. But I find a strong positive impact of being away five hours in terms of time zones. This means that as soon as the 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, my findings show that time zone differences of nine to eleven hours significantly raise affiliate sales again compared to the reference group. Especially countries in these areas suffer from high transaction cost due to a few or no overlapping in working hours and high

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)
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)	
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.

distances to the United States. The maximum time zone difference of 12 hours, where only few countries can be observed in the sample, has no significant impact. The coefficients for the other variables remain robust compared to my first specification. In addition, to the first model, all service sector dummies suggest a significantly positive impact on affiliate sales in comparison to the baseline group.
To account for the varying longitudinal distance within one group of pooled time zone differences I extend the third specification by including longitudinal as well as latitudinal distance in addition to the groups of time zones from the 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 the 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 the findings suggest that without crossing a time zone adding one kilometer to the East-West distance harms affiliate sales by 0.2%. The measure for North-South distance remains robust, although the impact of latitudinal distance increases compared to my first specification to 6% for an additional distance of 100 kilometers. With respect to the other explanatory variables the results are robust across the various specifications.

Overall, the specifications allow the conclusion that the results are quite robust and the methodology used is appropriate for my research question. This leads to the discussion of possible limitations of this study. Due to data limitations for affiliate sales statistics the study is based on U.S. outward affiliate sales, where the U.S. represents the only source country. Clearly, my research design would be enriched by building upon bilateral foreign affiliate sales data. Nevertheless, the empirical approach tries to overcome these caveats and to incorporate a model that does account for the data issues. Future research questions in this field could include the impact of distance components and time zone differences in goods trade in comparison to trade in services. Addi-

tionally, 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.[9]

4 Conclusions

This paper focuses on the impact of distance and time zone differences on trade in services through foreign affiliates. By decomposing distance into a longitudinal and latitudinal component to capture East-West and North-South distance separately, the paper aims to offer an alternative way to measure distance in terms of transaction costs. Additionally, as an alternative measure to geographic distance I 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%. My findings on increased time zone differences confirm this proximity burden. By moving further away from the Unites States in terms of time zones the results highlight 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 my results support the proposition that one has to account for various service sectors. I find that foreign affiliates especially play an important role for information intensive services, such as professional, scientific and technical as well as information services.

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

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

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 by foreign affiliates. Given the need for proximity in the provision of services, factors like distance place a higher cost burden on the delivery of services in foreign markets. In addition, differences in time zones add significantly to the cost of doing business abroad. Decomposing the impact of distance into a longitudinal and latitudinal component and accounting for differences in time zones, it is possible to 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 this paper examines the impact of time zone differences and East-West and North-South distance on U.S. outward affiliate sales. Both distance as well as time zone differences have a significant positive 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.

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