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Task dependence of U.S. service offshoring patterns

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Abstract

This work offers new insights into the determinants of service offshoring across countries and across service industries. Combining different data sources over the 2006-2009 period, I find that certain country characteristics affect offshoring costs for all services, while the effects of other characteristics depend on the coordination requirements of the respective service industry. The results from a zero-inflated Poisson pseudo-maximum likelihood estimation indicate that the effects of a membership in NAFTA, and a common colonial past on service offshoring patterns depend on the task content of the services. These results are robust to the control for unobservable country-level heterogeneity. The quality of legal institutions, a common legal origin, geographic distance, and time zone differences influence offshoring patterns identically across all service industries.

Keywords: Offshoring; Services; Tasks; Coordination, Poisson pseudo-maximum likelihood

JEL classification: F14; F23; F20

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1 Introduction

Compared with other trade phenomena, service offshoring has realized dynamic growth rates since the mid-1990s. The considerable decline in communication costs resulting from several technological improvements in the 1980s and 1990s has initiated a change in the way countries trade and has caused many service activities that were traditionally seen as non-tradable to become tradable. In the United States imports of computer and information services as well as other business services, which are mainly used as intermediate services by firms (e.g. Amiti and Wei 2005), more than tripled in real terms from 1995 to 2009.[1] However, because of data limitations, the empirical evidence on service offshoring is still fragmented. In this paper, I combine two prior strands of research to offer new insights on the determinants of U.S. service offshoring patterns.

Recent trade models that build on the concept of supermodularity offer theoretical guidance on how country and industry characteristics jointly influence the pattern of trade (Costinot 2009b). Thus far, the empirical analyses have focused on the interplay between institutional quality and industry-level institutional dependence. However, service industries do not differ only in their reliance on institutional quality. With the advent of offshoring, scholars have discovered that different types of services face different offshoring costs according to their *task content* (e.g. Garner 2004; Blinder 2006, 2007; Jensen and Kletzer 2005; Moncarz et al. 2008). For instance, many service occupations, such as those of general operations managers, still require "proximity" to other activities performed in the production process and are consequently more difficult to offshore. In particular, tasks differ in the degree to which they rely on coordination based on understanding and trust. I propose to proxy these coordination requirements by building on previous works that have emphasized the influence of different characteristics at the task level on an occupation's offshoring costs and to aggregate this information up to the industry level (see 3.2). This work also extends previous empirical works on the country-level determinants of services trade, which find for instance, that cultural distance (e.g. Kandilov and Grennes 2007; Miroudot et al. 2009; Head et al. 2009) and mutual membership in free trade agreements (e.g. Kandilov and Grennes 2007) affect bilateral services trade flows.

My analysis estimates whether and to what extent country characteristics and the task content of services jointly explain the U.S. service offshoring pattern. The intuitive relationship between task content and country-level determinants of coordination costs is new to the empirical literature and suggests a more nuanced story regarding the determinants of service offshoring patterns. The United States offers an especially interesting case for combining these two strands of research - i.e. the research on country characteristics and on task

[1] Because OECD data for these two service categories have only been collected since 2005, I employed data for the largest importer of these service categories (i.e. the United States) to illustrate the growth of imports since 1995. The United States is also the world's largest exporter of these services, and U.S. exports have also almost tripled in real terms from 1995 to 2009. All data are taken from the OECD Statistics on International Trade in Services.

content - because it is the top service-offshoring country in dollar amount and because the service sector is especially important in the U.S. economy.[2]

Methodologically, I build upon the work of Rajan and Zingales (1998) and estimate a gravity-like equation with interaction terms. Scholars have recently criticized the traditional approach of employing an OLS estimator in the context of the standard gravity model. Santos Silva and Tenreyro (2006) as well as Westerlund and Wilhelmsson (2006) have argued that estimates will be biased and inconsistent because of the presence of zero-values and heteroscedasticity. After performing a number of tests to determine the correct estimation technique, I estimate the gravity equation via zero-inflated Poisson pseudo-maximum likelihood (PPML).

My results indicate that services that depend to a high degree on understanding and trust are offshored relatively more to countries that are North American Free Trade Agreement (NAFTA) members, and that have a common colonial past with the United States. The quality of legal institutions, a common legal origin, geographic distance, and time zone differences influence offshoring patterns identically across all service industries, regardless of their coordination requirements.

The remainder of this paper is structured as follows. In section 2, I review the relevant literature on how the interplay between country and industry characteristics can shape patterns of comparative advantage and extend this approach to task-specific offshoring costs. Section 3 presents the data and the calculation of offshoring and coordination proxies. In section 4, I address econometric issues regarding the estimation techniques and present the estimation results. Section 5 summarizes the findings.

2 Theory and prior empirical research

Which theoretical trade models can guide the empirical analysis of trade patterns across countries and industries? Sharp predictions about trade patterns in neoclassical trade models, such as the Ricardian model and the Heckscher–Ohlin model, were traditionally derived in environments restricted to a small number of countries, goods, and factors. Unfortunately, these sharp results could not be preserved in settings with higher dimensionality, i.e. many goods and many countries. As a result, these standard models were difficult to apply to the data.[3]

The theoretical basis of my empirical analysis relies on the generalization

[2]For instance, 25 percent of all U.S. employment occurred in the business service sector in 2007 (see Jensen 2011, p.3f.)

[3]During the last ten years, the Ricardian trade model has experienced a revival because of Eaton and Kortum's (2002) stochastic version of the model. These researchers have developed a tractable general equilibrium model of international trade with multiple countries and goods that - unlike most traditional formal trade models - incorporates a role for geography. However, the Eaton and Kortum framework analyzes aggregate trade volumes rather than industry-level trade flows. Hence, their contribution offers only limited guidance for the present analysis, which also seeks to account for the cross-industry variation in offshoring patterns.

and extension of the sources of comparative advantage developed by Costinot (2009b). He develops an assignment model on the sources of comparative advantage that can be applied to differences in technology and to differences in factor endowments. The key concept in his model is log supermodularity, i.e. a mathematical notion of complementarity that captures the idea that the relative return to one variable is increasing in another variable. He shows that if factor productivity across different industries is log supermodular with respect to certain country characteristics γ, e.g. the quality of its financial system, and to certain industry characteristics σ, e.g. financial requirements, then aggregate output is also log supermodular. In other words, the productivity of sectors that have higher financial requirements is relatively more enhanced by a better financial system than the productivity of sectors that are less dependent on the quality of the financial system, i.e. log supermodularity of factor productivity. As a result, high-γ countries have a comparative advantage in high-σ industries.[4]

An emergent literature has provided microfoundations for the concept of log supermodularity by focusing on institutions. For instance, Costinot (2009a) assumes that complex products are produced by combining a large number of tasks and that production consequently requires many contracts with the workers performing the tasks. If the degree to which these contracts are enforced differs across countries, the products that have high "contractual input intensities" (Helpman 2006, p.23) will be relatively more exported from the countries in which contracts are strictly enforced by the legal system. Nicolini's (2007) empirical results support this hypothesis for the cross-country patterns of U.S. foreign direct investments (FDIs).[5]

However, in the context of service offshoring, industries do not only differ in their reliance on institutional quality. In addition to gains from specialization, the division of labor leads to transaction costs because of the need to coordinate different tasks. Offshoring implies "[...] cost[s] of exchanging information necessary to coordinate various tasks into a single production process," (Baldwin and Robert-Nicoud 2010, p.9) i.e. coordination costs. The higher the special-

[4]More formally, this case represents a Ricardian economy, in which factor productivity satisfies $q(\omega, \sigma, \gamma) = h(\omega)\, a(\sigma, \gamma)$. Where ω are characteristics of multiple factors of production, which are similarly productive across industries. Now assume that $a(\sigma, \gamma)$ is log supermodular. Thus, if $\gamma^{c1} \geq \gamma^{c2}$ and $\sigma^{s1} \geq \sigma^{s2}$ for any pair of countries c_1 and c_2 and for any pair of industries s_1 and s_2 and $a\left(\sigma^{s1}, \gamma^{c2}\right) \neq 0$ and $a\left(\sigma^{s2}, \gamma^{c2}\right) \neq 0$

$$\frac{a\left(\sigma^{s1}, \gamma^{c1}\right)}{a\left(\sigma^{s1}, \gamma^{c2}\right)} \geq \frac{a\left(\sigma^{s2}, \gamma^{c1}\right)}{a\left(\sigma^{s2}, \gamma^{c2}\right)}$$

In other words, factors in high-γ countries are relatively more productive in high-σ industries.

[5]Other empirical papers underpin the importance of "institutional dependence" and "institutional quality" (Costinot 2009b, p.1166) for the pattern of comparative advantage in the Ricardian sense, e.g. Nunn (2007) and Levchenko (2007). Manova (2006) focuses on credit market imperfections and Cunat and Melitz (2007) on labor market rigidities. See also Acemoglu et al. (2007) for a theoretical contribution analyzing how incomplete contracts and institutional cross-country variation can act as a source of comparative advantage. For a literature review on the incomplete contracts literature, see Helpman (2006).

ization of tasks, the more coordination among the specialists is needed for the production process to work (see Becker and Murphy 1992). With the advent of offshoring, it became clear that factors other than the degree of fragmentation influence the amount and type of coordination required. Different types of services face different offshoring costs according to their task content. In particular, tasks differ in the degree to which they rely on coordination based on understanding and trust. As emphasized by Leamer and Storper (2001), transactional relationships "[...] depend [to different degrees] on human relations, involving combinations of social networks, trust, interpretative communities, and reputation effects [...]." I propose to proxy these coordination requirements by building on previous works that have emphasized different characteristics at the task level as influencing an occupation's offshoring costs and aggregate this information up to the industry level (see 3.2). Because I focus not on the degree to which industries differ in their institutional dependence but rather on the degree to which services require understanding and trust, the set of country characteristics that could influence the pattern of offshoring shifts accordingly. In addition to the institutional quality of a country, several other determinants could be important in enhancing trust and understanding between two countries. I build on previous empirical works on the determinants of bilateral services trade flows and consider the linguistic distance between trading partners (e.g. Anderson and Marcouiller 2002), internet access (e.g. Freund and Weinhold 2002), cultural distance (e.g. Kandilov and Grennes 2007; Miroudot et al. 2009; Head et al. 2009), origin and quality of legal institutions (e.g. Head et al. 2009), membership in free trade agreements (e.g. Kandilov and Grennes 2007) and differences in time zones (e.g. Stein and Daude 2007) as country-level variables. Unlike these previous analyses, I focus on whether the effects of these country-level variables differ systematically with the task content of the respective service category.[6] My hypothesis is that if certain country characteristics reduce offshoring costs by enhancing understanding and trust, they are more important for industries that are highly complex and context-dependent. Hence, the pattern of bilateral service offshoring depends on the interplay between country characteristics and task content.

3 The Data

To test the hypothesis that U.S. service offshoring patterns depend on the interaction between coordination requirements and country characteristics, I need to

[6] Other empirical contributions on services trade have already shown that the effects of country-level characteristics, such as time zone differences, differ across service categories (e.g. Head et al. 2009). However, I am not aware of any other analysis that has tied these differences to the task content of the respective service categories. Oldenski (2012) estimates the interaction effects between task content and country characteristics to examine the decision between exports and horizontal FDIs. My work differs from her study by focusing on offshoring, rather than on modes of serving foreign markets, and by analyzing those task characteristics that were previously emphasized as influencing offshoring costs instead of focusing on communication and complexity.

construct several measures that are not directly available in the data. Section 3.1 provides details on the construction of the service offshoring proxy and presents the first evidence on U.S. service offshoring patterns across countries and industries. Section 3.2 determines the coordination requirements across different service industries and presents the resulting industry classifications. Section 3.3 describes the country-level characteristics that could influence coordination costs.

3.1 Offshoring proxy

Offshoring refers to the location rather than to the control over the production process.[7] As illustrated in figure 1, offshoring can take place via foreign direct investments (FDIs) and via international outsourcing (see e.g. van Welsum and Vickery 2005; Grossman and Rossi-Hansberg 2006; Feenstra 2010, p.5f).

Figure 1: Organization of the production process

	Location of production stages	
Control of production stages	Foreign country	Home country
In-house	**Foreign direct investment (FDI)**	Integration
Arms-length	**International outsourcing**	Domestic outsourcing

Source: Author's illustration adapted from van Welsum and Vickery (2005, p.5) and Feenstra (2010, p.5)

Unfortunately, no official data directly measure the volume of offshoring. However, offshoring can be measured indirectly. Because the intermediate services performed in a foreign country are likely to be imported back to the home country to be further integrated into the production process of the final good or service, offshoring can be expected to result in imports of intermediate inputs.[8] [9]

[7] Much of the recent trade literature analyzes the organizational choices of a global firm with regard to its boundaries. For a review, see Helpman (2006). In this paper, I will not address a firm's decision whether to keep activities in-house or to outsource them. Rather, I will focus on its decision in which country to locate the activities. This limitation follows not only from the research focus of this paper, but also from the data limitations. See footnote 13 for further information.

[8] An intermediate (input) is "[a]n input to production that has itself been produced and that, unlike capital, is used up in production. As an input, it is in contrast to a primary input, and as an output, it is in contrast to a final [product]." (Deardorff 2006, p. 144)

[9] Feenstra and Hanson (1996) were the first to proxy material offshoring by trade in intermediate inputs. I am not the first one to apply this approach to service offshoring. This approach has already been applied by Amiti and Wei (2005, 2006) and Crinò (2010).

For the United States, no official trade data separate trade in intermediate inputs from trade in final services.[10] By combining two data sources, i.e. input-output tables with bilateral cross-border services trade data, I can calculate an offshoring proxy for the United States for different offshored services and distinguish among different destination countries. I proceed in two steps.

In a first step, I estimate imported service intermediates. Building on Amiti and Wei (2005, 2006), the National Academy of Public Administration (2006, p.57ff.), and the OECD (2007b, p.51f.), I estimate the imported intermediates of a particular service by multiplying the value of the intermediate purchases of that service by the ratio of total imports to the total domestic supply of that service (see appendix A for further details):[11]

$$impint_{st} = \left[\frac{\sum_{c=1}^{C} SI_{sct}}{TSO_{st} + SI_{st} - SE_{st}} \right] SP_{st} \qquad (1)$$

$TSO \ldots$ Total Service Output
$SI \ldots$ Service Imports
$SE \ldots$ Service Exports
$SP \ldots$ Service Purchases
$s = 1 \ldots S$ Service
$t = 1 \ldots T$ Time
$c = 1 \ldots C$ Country

The BEA disaggregates bilateral trade data on total private services for the United States into *travel, passenger fares, other transportation, royalties and license fees* and *other private services*. I focus on the category of *other private services*, which excludes services such as tourism that are not subject to the offshoring debate and includes services such as management and legal services.[12] The *other private services* category aggregates many heterogeneous activities. From the year 2006 onwards, the BEA started to publish information by further decomposing this category for affiliated *and* unaffiliated trade.[13] These data offer an important improvement over earlier data collections because before 2006, statistics at this detailed level of service categories were only available for unaffiliated trade, and, hence, an important aspect of service offshoring had

[10] For more detailed analyses of the lack of detail available in services trade statistics see the reports by the U.S. Government Accountability Office (2004) and by the National Academy of Public Administration (2006, p.49f.).

[11] I assume that the import ratio of a certain service is the same irrespective of its use. In other words, if 10 percent of all financial services are imported, it will be assumed that 10 percent of all intermediate financial services are imported. An OECD report has calculated the aggregation bias associated with this assumption and the results suggest that the extent of imported intermediates tends to be biased downwards (Hatzichronoglou 2005, p.13).

[12] For a similar argument, see also Amiti and Wei (2006), Kandilov and Grennes (2007), and Head et al. (2009).

[13] It is not possible to further disentangle this information for affiliated and for unaffiliated trade. As a result, it is not possible to examine different impacts across the two rows of the column "Foreign country" in figure 1.

been ignored.[14]

The level of analysis is determined by the least disaggregated data. Unfortunately, input-output tables provide certain information only at a more aggregate service-category level than bilateral trade data. As a consequence, I can only calculate an offshoring proxy for the following seven subcategories of the *other private services* category: financial services, insurance services, telecommunications, computer and information services, legal services, management, consulting and public relations, and other business, professional, and technical services. Appendix A provides further descriptions of these subcategories and additional details on the data sources.

In a second step, I distinguish among different destination countries. I follow Egger and Egger (2003) as well as Miroudot et al. (2009) and weight the imported intermediate services obtained by (1) with the share of service imports from a certain country c in the worldwide imports of that respective service. After canceling, this value yields the volume of service offshoring across service categories and across trading partners:

$$off_{sct} = \left[\frac{SP_{st}}{TSO_{st} + SI_{st} - SE_{st}}\right] SI_{sct} \tag{2}$$

Figures 2 to 4 illustrate the results. Figure 2 shows the variation in offshoring volumes by service category and shows that in nominal dollar values insurance services constituted the top offshored service category from 2006 to 2009.

[14] With U.S. $74.125 millions in 2008, the services supplied within the boundaries of multinational companies (MNCs) accounted for almost one-third of the overall imports in other private services to the United States (in comparison, unaffiliated services imports accounted for U. S. $157.894 millions). This information is taken from the BEA Detailed statistics for cross-border trade .

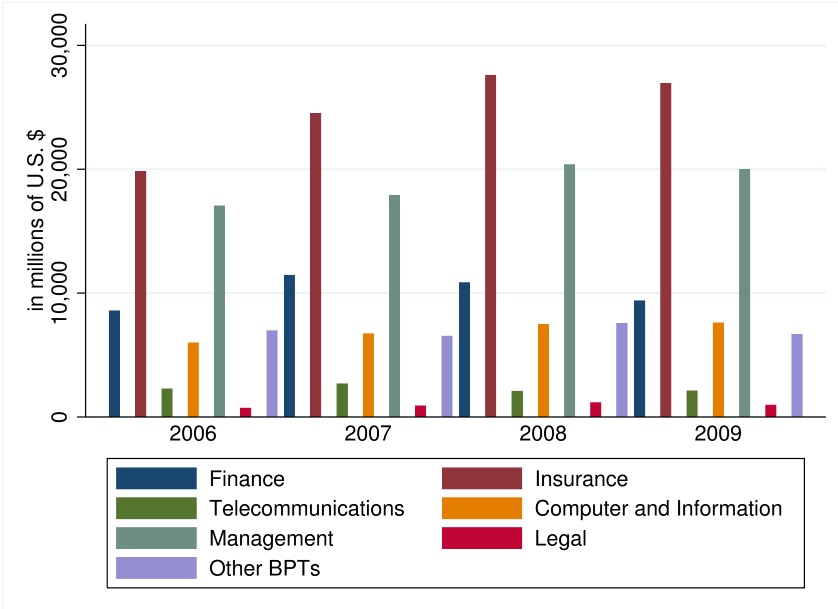

Figure 2: U.S. service offshoring by service category

Figure 3 shows that this picture changes if I control for the size of the service industry by normalizing the volume of offshoring with the gross production of the respective service industry.[15] After normalizing, I show that rather than insurance services, management, consulting and public relations become the service category whose share of gross production, i.e. roughly five percent, has been offshored the most over all four years. Although five percent might still be low, Amiti and Wei (2005) have shown that service offshoring grew rapidly at an average annual rate of 6.3 percent from 1992 to 2000.[16] Service offshoring has become increasingly important in accounting for overall services trade, i.e. services trade in final and intermediate services, and trade in intermediate services has accounted for roughly 73 percent of overall trade in services in 2006 (see also Miroudot et al. 2009). As figure 4 shows, the averages over all destination countries hide significant variation across countries within each service category. For instance, computer and information services are mainly offshored to India, whereas legal services are mainly offshored to Great Britain and Canada. This heterogeneous cross-country pattern across service categories motivates the present analysis.

[15]For details, see equation (6) in appendix A. This normalization also considers the concern that during the sample period gross production of financial services could have been distorted due to the financial crisis.

[16]Before the mid-1990s offshoring primarily concerned manufacturing activities, and the scale of service offshoring was close to zero (see e.g. Crinò 2009). In contrast to service offshoring, the estimates by the OECD (2007a, p.111ff.) suggest that the growth rate of material offshoring started to slow down in the second half of the 1990s.

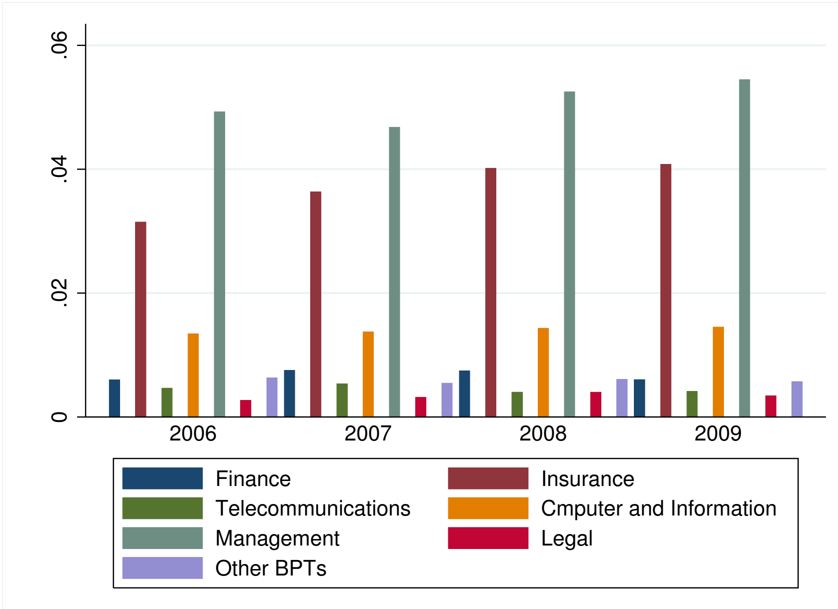

Figure 3: U.S. service offshoring as a share in gross production per service

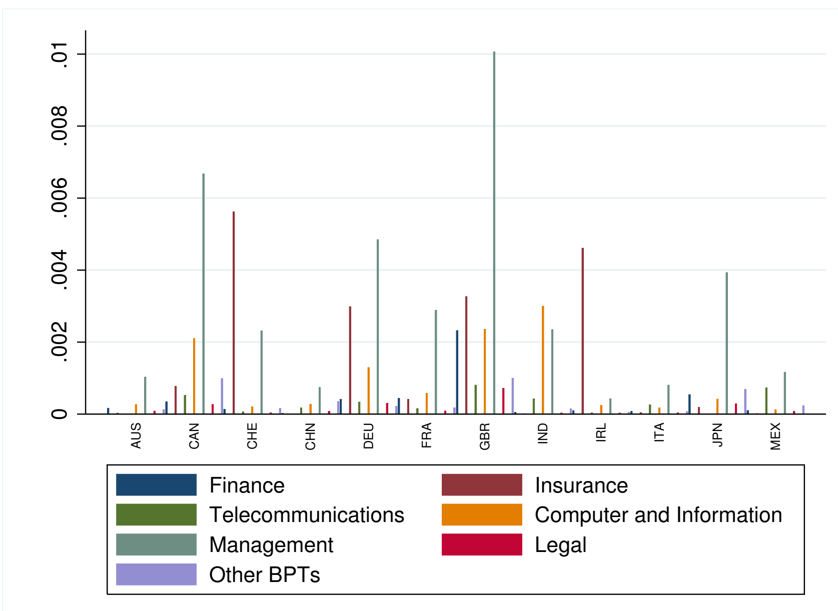

Figure 4: U.S. service offshoring as a share of gross production per service across countries and services in 2006

3.2 Coordination requirements

Another difficulty in testing the joint impact of coordination requirements and country-level characteristics stems from the fact that coordination requirements at the industry level are not observable in the data. Therefore, I construct a proxy for a service industry's coordination requirements by employing the classification provided in Moncarz et al. (2008).[17] They report the results of a classification scheme developed by more than 20 economists from the Bureau of Labor Statistics (BLS) Employment Projections Program. I decided to employ the ranking developed by Moncarz et al. (2008) for two reasons. First, instead of emphasizing one particular task characteristic, their ranking is very comprehensive. It is based on the characteristics of occupations that were emphasized to different degrees by several other contributions as influencing the costs of offshoring (e.g. Bardhan and Kroll 2003; Garner 2004; Jensen and Kletzer 2005; van Welsum and Vickery 2005; Blinder 2006). The common insight of these contributions is that the task content of different occupations affects the costs of offshoring, regardless of the country to which they are offshored. Second, unlike most of the other contributions, Moncarz et al. have established a continuous ranking of a task's offshorability. A dichotomy that instead classifies tasks as either offshorable or non-offshorable would not be useful in the present analysis because I am interested in the differences in offshoring costs within the group of offshorable tasks.[18]

The economists of the BLS Employment Projections Program proceeded as follows. First, they identified 355 of the 515 service occupations in the Standard Occupational Classification System (SOC)[19] as non-tradable. The occupations that were classified as non-tradable include those services that require face-to-face contact with customers (e.g. barbers) or need to be performed in a fixed location (e.g. security guards). In a second step, the economists assigned all other service occupations an "offshoring susceptibility" score,[20] which depends on the degree to which they comply with different criteria. In the following, I explain for which coordination requirements this "susceptibility" score serves as a proxy.

Some tasks inherently require more coordination than other tasks. For instance, managers have to stay in contact with the different departments of a firm, whereas computer programmers only interact with parts of the firm. Levy and Murnane (2006) argue that routine occupations are typically the easiest ones to offshore because they are easy to explain and easy to monitor.[21] In

[17] Note that the resulting proxy has an ordinal rather than a cardinal scale.

[18] The only other continuous ranking thus far is the one developed by Blinder (2007).

[19] For further details, see appendix B.

[20] Note that one has to be careful when using the term "offshoring susceptibility". The actual pattern of offshoring depends on both the potential costs and the potential benefits, which are not considered in this ranking. Furthermore, as argued in the present analysis, the actual costs also depend on the interplay between task content and country characteristics. The classification by Moncarz et al. (2008) ranks tasks according to their inherent offshoring costs.

[21] Moncarz et al. (2008) address this issue with the following two questions: "[...] To what degree do the duties of this occupation require interaction with other types of workers?" and

the context of the literature on institutions and trade, this finding has been interpreted as indicating the degree to which tasks rely on successful contract enforcement. However, "easy" also means that there are fewer prerequisites necessary for a successful exchange of information. Leamer and Storper (2001) argue that once people have acquired the underlying symbol systems (e.g. language and mathematical skills), these symbols can be used to communicate the required information and instructions as well as to monitor the results of routine tasks and tasks that are based on codifiable information. As a result, these tasks can be easily conveyed at a distance. On the contrary, complex, tacit information cannot be transmitted solely through the acquisition of the respective symbol system. Successful performance requires mutual understanding and trust because some information is context-dependent. For instance, many marketing occupations may not be performed very successfully without familiarity with the target market.[22]

Based on the compliance with these criteria, the BLS economists ranked each of the service occupations. By using the information provided in the industry-specific occupational employment and wage estimates of the BLS,[23] I can aggregate the occupation-level information[24] provided in Moncarz et al. (2008) up to the service-category level. This aggregation is necessary because the offshoring proxy is calculated at the service-industry level according to the NAICS categories (see 3.1). More specifically, I calculate a weighted average for each of the seven service categories by weighting the offshoring score for each occupation o with the share of occupational employment in total employment across all occupations within a given service category s:[25]

$$OFFscore_s = \frac{\sum_{o=1}^{O} (offscore_o totemp_{os})}{totemp_s} \qquad (3)$$

I normalize this industry-level score in such a way that it lies between zero

"[...] To what degree can the work of the occupation be routinized or handled by following a script?" (Moncarz et al. 2008, p.75)

[22] Moncarz et al. (2008) consider two different criteria. "[...] To what degree can the inputs and outputs of the occupation be transmitted electronically, or otherwise be easily and cheaply transported?" and "[...] To what degree is knowledge of social and cultural idiosyncrasies, or other local knowledge, of the target market needed to carry out the tasks of this occupation?" (Moncarz et al. 2008, p.75)

[23] Publicly accessible at the BLS website.

[24] This level of analysis is important because some occupations are tradable even though they are performed for industries whose final products would be categorized as non-tradable (see also Jensen and Kletzer 2005).

[25] Even if offshoring does not necessarily imply layoffs of workers in the home country, it can still change relative employment and hence the occupational composition within industries such that using older data would have been preferable in this context. Derimoglu gives an example that helps to illustrate this point: "[...] consider a firm that expands its back office jobs by hiring abroad rather than in the United States — that expansion would not displace U.S. workers, but it would be a case of offshoring, as the firm substitutes production abroad for its production in the United States" (Derimoglu 2006, p.5). However, the year 2003 is the first year for which information on occupational employment is based on the 2002 NAICS coding structure. This feature renders the data compatible with the classification utilized in the trade data and in the input-output data.

and one, with one indicating the lowest susceptibility to offshoring and zero indicating the highest offshoring susceptibility. Figure 6 shows the resulting classification across the seven service categories. Insurance services are classified as the most prone to offshoring, whereas management, consulting, and public relations are the least susceptible to offshoring. Hence, this ranking indicates that management, consulting, and public relations have the highest requirements for coordination based on understanding and trust, whereas insurance services depend the least on these prerequisites.

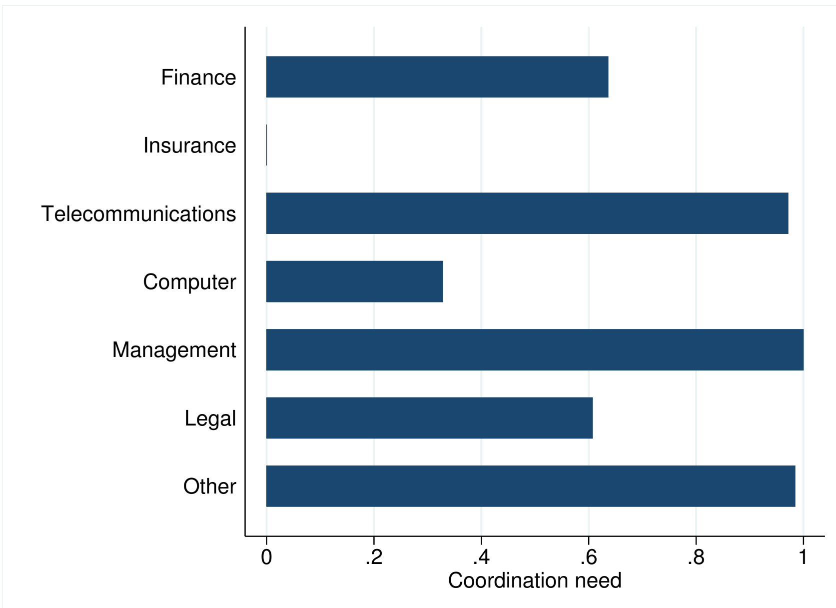

Figure 5: Offshoring score per service category

3.3 Country-level determinants

By requiring more prerequisites, the task content described in 3.2 influences the costs that arise from the fragmentation of the production process, regardless of whether this fragmentation takes place within or across country borders. In the context of offshoring, this fragmentation can incur extra costs because it occurs across international borders. Several country-level variables have been found to influence the bilateral volume of services trade. Rather than concentrating on production or transport costs, I focus on the characteristics that could influence the coordination costs[26] between the home and destination countries. Following previous empirical works, I concentrate on the following set of country-level determinants: common language, cultural similarity, FTA membership, geo-

[26]Production costs are affected, for instance, by the productivity-adjusted wages in the destination country.

graphic distance, internet penetration, common legal origins, quality of legal institutions, and differences in time zones. In the following, I explain in more detail how each of these characteristics could influence the coordination costs for services that are highly complex and context-dependent. Table 1 summarizes the expected signs of the effect of each country-level variable.[27]

Crémer et al. (2007) have argued that communication and thus coordination are easier within firms because they have developed a common "language" and share common norms and values. Accordingly, coordination failures can be expected to be less frequent if people speak the same language and fewer misunderstandings occur as a result. Head et al.'s (2009) results suggest that countries sharing a *common language* tend to have higher bilateral services trade flows.

Even if the populations of the two countries do not speak the same language, citizens can be familiar with the cultural idiosyncrasies of the other country. Familiarity can be expected to go hand in hand with higher levels of trust and understanding, which, in turn, facilitate coordination. Unlike the results for goods trade, the results for services trade have not yet provided clear evidence regarding the impact of past colonial ties as a proxy for *cultural similarity* (see e.g. Kandilov and Grennes 2007; Head et al. 2009).

I also include a dummy variable for the North American Free Trade Agreement (NAFTA). Even if FTAs are designed to enhance goods trade, the resulting intensified trade relationships could also facilitate coordination via a greater familiarity with local conditions. In line with this argument, Kandilov and Grennes (2007) as well as Manning et al. (2009) have provided evidence that *mutual membership in a free trade agreement* positively impacts the volume of services trade between two countries.[28]

Many scholars argue that *geographic distance* does not have a significant impact on service offshoring. Because services are transported electronically, the transport costs for services – unlike those for goods – do not depend on the geographic distance over which the service is transmitted (e.g. Blinder 2006).[29] In this context, it is important to emphasize that I focus on a different channel through which country characteristics influence offshoring patterns. Rather than concentrating on transport costs, I focus on coordination costs. Because travel costs tend to be higher over long distances, people tend to have fewer travel experiences, and geographic distance can proxy for unfamiliarity (see e.g. Grossman 1996). For instance, the first instances of service offshoring occurred among trading partners that were geographically relatively close to each other.[30]

[27] For details on the data sources and the construction of these country-level variables, see appendix C.

[28] A common border dummy is another control often included in gravity equations. However, because I only consider the United States as the offshoring country, the NAFTA dummy is identical to a common border dummy.

[29] Accordingly, Kandilov and Grennes (2007) find that geographic distance has no explanatory power for services trade after controlling for the effect of networks, such as internet penetration and telephone call traffic among trading partners.

[30] An early instance of service offshoring was the offshoring of design tasks to Germany by the British motor industry in 1979 (see Amiti and Wei 2004).

Accordingly, Head et al. (2009) find evidence that geographic distance negatively affects the volume of services trade.

Developments in Information and Communication Technologies (ICTs), such as the emergence of the Internet and the World Wide Web during the 1980s and 1990s, have significantly reduced the costs of the almost real-time transmission of instructions and information.[31] The security of these data transmissions has also been enhanced by the increasing use of encrypted private networks, such as virtual private networks (VPN) (e.g. GAO 2004, p.10f.). As Freund and Weinhold (2002) have shown, *internet penetration* has a strong positive effect on trade in services (see also Kandilov and Grennes 2007). However, as Leamer and Storper (2001) have argued, whether enhanced internet penetration will lead to higher trust or understanding is less clear. Hence, I do not expect the positive effect of ICTs to differ according to the coordination requirements of the respective service industries.

According to the incomplete contracts literature mentioned above, and empirical results e.g. by Anderson and Marcouiller (2002), the *quality of the legal system* enhances the security of contract enforcement, property rights etc. Furthermore, a *similar legal system* reduces the cost of gathering information about the relevant rules in the partner country. Both characteristics could enhance formal trust (see e.g. Anderson 2000, Huang 2007) and thereby facilitate coordination.

In addition to these characteristics, *time zone differences* could also impact coordination costs. On the one hand, time zone differences can lead to offshoring benefits because they offer the possibility of providing certain services, such as call centers, around the clock ("continuity effect"). On the other hand, time zone differences complicate real-time communication during business hours ("synchronization effect"; see Head et al. 2009, p.435) and thus hamper coordination. Hence, the overall effect is not clear, and previous works have not yet found clear evidence on this matter (see e.g. Head et al. 2009).

Table 1: Effect of country-level characteristics on coordination costs

Variables	Expected Sign
common language	-
colonial ties	-
geographic distance	+
ICT penetration	-
quality of legal institutions	-
common legal origins	-
time zone difference	+ / -

[31] The significant growth of the global telecommunications infrastructure in 1990 was facilitated by the immense investments in fiberoptic cables during the dot-com boom. In particular, the bust in 2001 has enabled many – also developing – countries to use these networks almost for free and thus gave another boost to offshoring (see e.g. U.S. Government Accountability Office 2004, p.10; Derimoglu 2006).

4 Econometric analysis

I estimate variants of the following equation to examine the joint impact of country-level characteristics and coordination requirements on U.S. service offshoring patterns:

$$OFF_{sct} = \exp\left(c + \beta X_s * Z_c + \gamma Z_c + \delta X_s + d_i + \varepsilon_{sct}\right) \quad (4)$$

$s = 1 \ldots S$ *Service*
$t = 1 \ldots T$ *Time*
$c = 1 \ldots C$ *Country*

OFF_{sct} is the volume of U.S. service offshoring to country c, divided by the gross production in service industry s in year t. I perform this normalization to make the coefficient comparable across industries and to account for industry size. X_s is the proxy for the coordination requirements of service industry s, Z_c is a vector of country characteristics, $X_s * Z_c$ is a set of interactions between different country characteristics and the coordination requirement proxy, and d_i is a set of time and/or country fixed effects.[32]

Equation (4) resembles a gravity equation.[33] Usually, scholars employ gravity equations to estimate the effects of different country characteristics on bilateral trade flows. The present analysis addresses the differential impact of country characteristics across service categories that is of interest, i.e. the coefficient β on the interactions.[34] An example will help to illustrate this idea. The country-level variables that are assumed to affect communication costs include cultural similarity. If the origin and destination countries share certain norms and values, these shared attributes will facilitate communication and thus coordination between the countries. As a consequence, I expect cultural similarity to have a positive effect on the expected volume of service offshoring. Depending on the specification, this positive impact across all services is captured by either the coefficient γ_c or the country fixed effect. In addition, I expect the impact of cultural similarity to be particularly strong for those services that have higher requirements for coordination based on understanding and trust, e.g. complex services. Because the offshoring susceptibility score rankings are proxying for increasing coordination requirements, a positive coefficient β on the interaction term would support this idea.

[32]Because my proxy of coordination requirements is collinear with service industry fixed effects, these effects are excluded.

[33]Gravity models predict that the volumes of bilateral trade flows depend upon "centrifugal" and "centripetal forces" (Baldwin and Venables 2010, p.3) that differ across trading partners. For a recent survey of the theoretical foundations and specifications, see Baldwin and Taglioni (2006).

[34]Interaction terms were first included into a gravity equation by Rajan and Zingales (1998) in their analysis of the joint impact of financial development and financial requirements on industry growth. More recently, e.g. Levchenko (2007) and Chor (2010) have developed similar functional forms to estimate the interplay between country and industry characteristics on the pattern of trade.

4.1 Discussion of estimation methods

In the following paragraphs, I present the dataset and examine the appropriateness of different estimators that have been discussed in the recent turn in the scholarly discourse towards the challenges of the econometric estimation of the gravity model.[35]

Traditionally, scholars have estimated multiplicative models, such as the gravity equation, by taking the logarithm to transform these models into an additive form before employing an OLS estimator. However, this estimation approach suffers from two flaws. First, it cannot handle data that are rich in zero-value observations because the logarithm is not defined for non-positive values. As a consequence, many previous empirical studies have dropped the zero-value observations (e.g. Levchenko 2007; Chor 2010). However, these zero observations[36] also depend on the regressors because they are more likely to occur, for instance, for distant countries. Thus, dropping the zero-value observations implies a selection bias because the sample is no longer random (see e.g. Westerlund and Wilhelmsson 2006).[37]

Santos Silva and Tenreyro (2006) emphasize a second problem. Even under the assumption that the dependent variable only takes on positive values, an OLS estimation of the logarithmic transformation has to address the problem of inherent heteroscedasticity, which can lead to inconsistent estimates. Even if the mean of the error term in the original model is independent of the regressors, if heteroscedasticity is present, the expected value of the logarithm of the error term is a function of the covariates because the expected value of the logarithm of a random variable also depends on its higher-order moments, such as the variance (see also Winkelmann 2008, p.97ff.).[38]

As a solution to both problems, Santos Silva and Tenreyro (2006) propose to directly estimate the multiplicative form of the model with a Poisson pseudo-maximum likelihood (PPML) estimator. The basic Poisson regression model assumes a conditional Poisson distribution for the dependent variable. In other words, the density of the dependent variable is determined entirely by the conditional mean because the conditional variance and mean are assumed to be equal such that $E(y|x) = V(y|x)$. However, the Poisson estimators are con-

[35] The recent focus on econometric issues was initiated byAnderson and van Wincoop's (2003) claim that the traditional gravity equation has been misspecified because it only considers absolute measures as regressors and does not control for relative ones. They suggest augmenting it by introducing multilateral resistance terms, which are often proxied by remoteness indices. As has been shown by Feenstra (2004, p.161ff.), an alternative approach that also leads to consistent estimates is to introduce exporter and importer fixed effects.

[36] Trade values will also be registered as zero observations if they do not reach a certain minimum value, which is U.S. $500,000 for the United States.

[37] According to the Monte Carlo simulations conducted by Santos Silva and Tenreyro (2006), other procedures will also lead to inconsistent and biased estimators to different degrees. These approaches include the use of a Tobit estimator (e.g. Felbermayer and Kohler 2004) and the replacement of $Y_{sct} = 0$ with $Y_{sct} + 1$, , which is followed by the estimation with OLS (e.g. Nicolini 2007).

[38] Santos Silva's and Tenreyro's (2006) illustration focuses on the gravity model but their criticism applies to constant-elasticity models and the OLS estimation of their non-linear transformations in general.

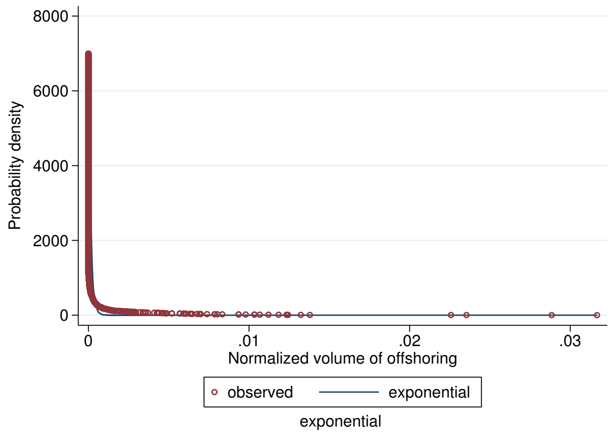

Figure 6: density probability plot exponential

sistent even if the dependent variable is not a count variable and the underlying distribution is not Poisson. According to maximum likelihood theory, for the estimator to be consistent, the conditional mean of the dependent variable needs to be correctly specified by a distribution belonging to the linear exponential family, i.e. $E\left[y_i\left|x\right.\right] = \exp\left(x_i\beta\right)$ (see e.g. Gourieroux et al. 1984). Plotting the empirical and theoretical density probabilities in figure 6, I find that the exponential distribution seems to describe the data well. Another advantage offered by the exponential distribution is that it accounts for the fact that offshoring flows can be zero but not negative.

A potential problem is that the data exhibit overdispersion (i.e. the mean is smaller than the variance). Hence, the assumption that the conditional variance is proportional to the conditional mean is violated. As a result, the standard errors will be downward biased, and z-values will be misleadingly large and p-values misleadingly small (see Long and Freese 2006, p.376). Overdispersion maybe addressed through the application of a negative binomial model (NB).[39] In this case, the variance depends not only on the conditional mean, but also on a dispersion parameter. Whether the Poisson or the negative binomial regression model is a better fit to the data can be tested by applying a likelihood ratio test for overdispersion. If the dispersion parameter alpha is zero, the NB model reduces to the Poisson model (see Cameron and Trivedi 2010, p.577ff.; Long and Freese 2006, p.407ff.). This case applies to the present analysis, and there is no significant evidence of overdispersion ($G^2 = 3.3e - 05$, $p = 0.498$).[40]

Another problem I could encounter are "excess" zeroes (i.e. there would be

[39]Santos Silva and Tenreyro suggest basing inferences on Eicker-White robust standard errors to solve this problem.

[40]The likelihood ratio test statistic is based on the difference between the two log-likelihood values; the distribution is a mixture of a chi-squared distribution with no degrees of freedom and a chi-squared distribution with one degree of freedom (see Winkelmann 2008, p.113f.).

more zero observations than would be predicted by a Poisson model).[41] This problem can be addressed by applying zero-inflated models, such as the zero-inflated Poisson model (ZIP). Zero-inflated models are based on the assumption that zero observations can result from two different data generating processes. In the inflated part of the regression model the effects on the probability of observing zero offshoring volumes are estimated by a logit model, $P\ (y = 0 \ |x\ )$. This probability may depend e.g. on geographic distance but also on other factors, such as trade embargoes, that do not influence the volume of offshoring. Then, in a second step, the impact of the regressors on the volume of offshoring (which can also be zero) is estimated by a Poisson model for all observations that have a non-zero probability of offshoring (see Cameron and Trivedi 2010, p.599ff.). In other words, also countries that are not receiving any offshored services in a certain year or a certain service category are included in this sample because they could potentially have obtained offshored services.[42] As a result, the effects of the regressors are allowed to differ for offshoring flows that have a zero probability and for those that have a non-zero probability of offshoring. To compare the standard Poisson model and the zero-inflated regression model, I employ the Vuong test. Under the null hypothesis that the probability of being in the "always zero" group is zero, the test statistic has an asymptotic standard normal distribution. Large positive values indicate that the zero-inflated version is more appropriate, whereas large negative values favor the standard model (see e.g. Long and Freese 2006, p.408f.). The Vuong test shows that the zero-inflated Poisson regression is a better fit for the data than the standard Poisson model (z-value of 34.29). As a result of the different tests performed, I estimate equation (4) via a zero-inflated Poisson (ZIP) regression model.[43]

4.2 Estimation results

This section examines the estimation results for the ZIP regression. Table 2 reports the estimates of equation (4), with column (1) presenting the baseline results. The results in column (2) are based on clustered standard errors at the country level, and column (3) presents the preferred specification.[44]

[41] According to Greene (1994), excess zeroes can "masquerade" as overdispersion, and it is important to disentangle both problems because different methods can address them. In other words, even if the negative binomial model can deal with the problem of overdispersion due to unobserved heterogeneity, unlike zero-inflated models, it assumes the same data generating process for zero observations and hence does not control for unobserved heterogeneity across zero observations.

[42] More precisely, zero-inflated models allow for two types of zeroes (unlike hurdle models, which allow for only one type of zero). See Winkelmann (2008, p.188ff.). See also Burger et al. (2009) for a recent overview of these estimation techniques in the context of the gravity equation.

[43] The ZIP and the zero-inflated negative binomial (ZINB) are nested, so that both models can be compared by applying a likelihood-ratio test. The results from this test can be obtained upon request and also provide evidence for preferring the ZIP over the ZINB.

[44] The regression results for the inflated part of the ZIP regression are suppressed because none of the regressors is statistically significant at any of the conventional levels. These results

Table 2: Zero-inflated Poisson regression

	(1) ZIP	(2) ZIP	(3) ZIP
Offshorability score	-25.88***	-25.88	-33.06*
	(7.732)	(16.91)	(15.96)
Skill intensity	1.234	1.234	1.047
	(0.750)	(1.348)	(1.309)
Skill endowment	0.0596	0.0596	-0.0873
	(0.527)	(1.087)	(1.100)
*skill intensity	-1.063	-1.063	-0.784
	(0.828)	(1.599)	(1.425)
Rule of law	7.125***	7.125	6.317
	(1.364)	(3.870)	(3.935)
*offshorability score	-2.149	-2.149	
	(1.751)	(2.321)	
Common legal origin	0.788**	0.788	0.588
	(0.264)	(0.614)	(0.415)
*offshorability score	-0.431	-0.431	
	(0.521)	(0.797)	
Common language	0.307	0.307	0.462
	(0.252)	(0.562)	(0.599)
*offshorability score	-0.911	-0.911	-1.370
	(0.571)	(0.899)	(1.085)
colonial past	0.939**	0.939	0.896
	(0.331)	(0.572)	(0.593)
*offshorability score	2.043**	2.043*	2.343*
	(0.710)	(0.975)	(0.959)
NAFTA	-3.463*	-3.463	-3.682
	(1.700)	(4.118)	(3.891)

are available upon request.

Table 2: continued

	(1) ZIP	(2) ZIP	(3) ZIP
*offshorability score	9.796***	9.796*	11.06**
	(2.130)	(4.482)	(4.240)
Time zone differences	0.276**	0.276	0.294
	(0.0855)	(0.248)	(0.235)
*offshorability score	-0.0521	-0.0521	-0.0910
	(0.131)	(0.309)	(0.290)
log(Geographic distance)	-2.334**	-2.334	-2.489
	(0.711)	(1.913)	(1.812)
*offshorability score	3.090**	3.090	3.703
	(0.942)	(2.113)	(1.986)
Internet penetration	0.000607	0.000607	0.000596
	(0.000509)	(0.000932)	(0.000765)
*offshorability score	-0.000185	-0.000185	
	(0.00114)	(0.00136)	
log(GDP per capita)	-0.153	-0.153	-0.160
	(0.219)	(0.619)	(0.606)
Fixed effects	Year	Year	Year
Observations	3724	3724	3724
Log pseudolikelihood	-4.6577169	-4.657717	-4.661246

Columns (1): Robust standard errors in parentheses;
Columns (2) and (3): Clustered standard errors at the country level in parentheses;
* significant at 10%; ** significant at 5%; *** significant at 1%

One obvious concern is that the estimates of equation (4) could be biased because of omitted variables. Hence, in addition to the variables of interest, I include control variables for alternative determinants of the service offshoring patterns that could be correlated with (parts of) the interaction terms. In particular, I include a proxy for skill intensity at the industry level, a proxy for skill endowments at the country level,[45] their interaction term, and a wage

[45]One limitation of the present analysis is the assumption that coordination costs depend solely on the characteristics of tasks and countries. Hence, workers are assumed to be homogeneous in their coordination skills. This assumption is due to the fact that there is no available measure of cross-country coordination and hence communication skills. Because skill is not a unidimensional concept, general skill endowments do not necessarily offer information

proxy, i.e. GDP per capita.[46]

The result in column (1) of table 2 implies that an increase in the offshoring susceptibility score decreases the expected share of offshoring. This finding suggests that an increase in the offshoring susceptibility score indicates an increase in offshoring costs. As argued in 3.2, these offshoring costs are driven by higher coordination requirements. This result is also economically significant in magnitude and indicates, ceteris paribus, that for a one standard deviation increase in the offshoring susceptibility score, roughly 0.29, the expected share of offshoring decreases by roughly 99 percent.

In line with previous findings, I find that the higher the quality of a country's legal environment, as measured by the Kaufman et al. (2009) rule of law index, the higher is the expected share of offshored services that a country attracts. This result is significant at the 1 percent level. With respect to the magnitude of this effect, the ZIP specification in column (1) suggests that a one standard deviation increase in the quality of legal institutions, roughly 0.21, increases the expected share of offshoring by a factor of 4.46.

Similar to the quality of legal institutions, a common legal origin (i.e. UK legal origins), a common colonial past, and time zone differences positively affect the expected service offshoring flows from the United States, whereas geographic distance and being a member of NAFTA decrease the expected offshoring flows. The coefficients on the common language dummy and on internet penetration are not statistically significant at any of the conventional levels.

Let us now focus on the discussion of the results regarding the interaction effects. The coefficients on the respective interaction terms with the coordination proxy are not statistically significant at any of the conventional levels for the following variables: the quality of legal institutions, a common legal origin (i.e. UK legal origins), a common language, internet penetration, and time zone differences. This finding does not imply that these variables do not affect offshoring; it only suggests that they do not significantly affect the relative offshoring shares of services that are characterized by a high degree of complexity and context-dependency. Put differently, regardless of the task content of the respective service, these country-level characteristics affect the expected share of offshoring in the same way.

The coefficients on the interaction terms with the NAFTA dummy, the common colonial past dummy and geographic distance are all positive and statistically significant at least at the five percent level. I further test for robustness of these interaction effects. First, I base the inference in the Poisson pseudo-maximum likelihood regression on clustered standard errors at the country level.

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on communication skills. For instance, an OECD (2000) survey has identified and measured three different dimensions of literacy across 20 countries, i.e. prose literacy, document literacy and quantitative literacy. In 2013, the new results of a more comprehensive OECD survey will be published (see OECD 2009). These results will offer an interesting extension to the present analysis. One could imagine analyzing the interaction effects between these more detailed skill endowments of a country and the task content.

[46] Skill endowments are measured by the average years of tertiary schooling in a country, and skill intensity is measured by the share of college graduates in the overall employment of an industry. See appendix C for additional details on the data sources.

Column (2) in table 2 shows the results. The results regarding the interaction effects of NAFTA and a common colonial past are robust to this additional control, whereas the interaction effect with geographic distance loses statistical significance. Second, I estimate a ZIP regression with clustered standard errors without those interaction effects that were not significantly different from zero at the 10 percent significance level. Column (3) presents the results and shows that the interaction effects with the NAFTA dummy and the colonial past dummy are, again, robust to this alternative estimation.[47] Let us now turn towards the economic interpretation of these interaction effects, in which we focus on the results in column (3).[48]

A common colonial past increases the expected share of offshoring (see column (1)). The positive and significant interaction term suggests that this effect is even stronger for those services with a relatively high degree of coordination requirements. As past colonial ties proxy for cultural similarity, this result is consistent with expectations. A higher cultural familiarity enhances trust and understanding and is especially important for exchanges of information that relies primarily on mutual understanding. With respect to economic magnitude, let us focus on two services, i.e. management and consulting services as well as financial services, and on two countries, i.e. the United Kingdom and Germany. These two industries and countries offer special cases for which the calculation of the economic magnitude is easily illustrated. The reason for this is that the common colonial dummy is one for the United Kingdom and zero for Germany, and, similarly, the offshoring susceptibility is zero for financial services as compared to one for management/consulting services. The coefficient on the interaction term in column (3) implies that, ceteris paribus, the offshoring flows of management and consulting services (relative to financial services) are higher in the United Kingdom than in Germany by a factor of 10.41.[49]

The NAFTA dummy has a differential impact depending on the service industry's task content. For the services that rely the least on understanding and trust, the expected share of offshoring is lower for Canada and Mexico (see column (1)). For those services that require more prerequisites for successful coordination, the expected share of offshoring increases for NAFTA countries. One economic interpretation is that for highly complex, context-dependent services,

[47]Table 10 in appendix D shows the results for the stepwise deletion of insignificant variables. Note that the interaction terms with NAFTA and common colonial past are statistically significant in each of these steps.

[48]Unfortunately, the zero-inflated Poisson regression cannot yet be extended to a fixed-effect estimator (see Winkelmann 2008, p. 227). However, the Poisson pseudo-maximum likelihood estimator can be extended to a fixed-effect Poisson pseudo-maximum likelihood estimator (see Westerlund and Wilhelmson 2006). To further check the robustness of the interaction effects with regard to potential unobserved country heterogeneity, I also performed a fixed-effect Poisson quasi-maximum likelihood regression. The interaction effects are, again, statistically significant and have the same signs. The economic magnitude is similar, but slightly smaller. Results are available upon request from the author.

[49]See Winkelmann (2008, p.71f.) for the proof that

$$E\left[\tfrac{Z_c=1, X_s=1}{Z_c=1, X_s=0} / \tfrac{Z_c=0, X_s=1}{Z_c=0, X_s=0}\right] = \exp(\beta)$$

offshoring costs also depend on smooth communication and understanding, and the respective coordination is easier with those countries either because of the experiences already gained in previous trade relations or because these countries have a common border with the United States. Note that I cannot disentangle these two reasons because they are perfectly collinear in the present analysis. The result in column (3) implies that, ceteris paribus, for a one standard deviation increase in the coordination proxy, service offshoring flows are higher in Canada than in Germany by a factor of 24.71.[50]

5 Conclusion

Service offshoring is currently one of the most dynamic and heatedly debated aspects of international trade in both academia and politics. However, because of data limitations, few empirical studies have examined trade in services. This paper offers new evidence on the determinants of U.S. service offshoring by matching data on the task content of service industries with bilateral services trade data and input-output data from the Bureau of Economic Analysis.

The intuitive relationship between coordination requirements based on the task content and country-level determinants of services trade is new to the empirical literature and offers insights on the mechanism through which country characteristics affect offshoring patterns. Much of the recent literature in international trade and in labor economics has argued that offshoring costs differ across services according to their task content. By employing disaggregated trade data for the United States, I was able to analyze the interplay between task characteristics and characteristics at the country level. This interplay led to offshoring patterns that differ across countries and across services. In particular, I have focused on how this interplay influences coordination costs based on understanding and trust.

The present results suggest that the interaction between task characteristics and country characteristics is important to the effects of a common colonial past, and of a membership in NAFTA. These interaction effects are robust to the control for unobservable country heterogeneity. This evidence extends previous empirical works on the country-level determinants of service offshoring and suggests a more nuanced story. A better quality of legal institutions, a common legal origin, geographic distance, and time zone differences influence offshoring patterns identically across all service industries, regardless of their coordination requirements.

Many scholars have argued that services will become increasingly tradable because of technological progress. These scholars argue that technological change

[50] Nunn (2007) emphasizes that there could be reverse causal influence, i.e. the pattern of specialization influences institutional features, such as the quality of legal institutions. Hence, he replaces his measure of institutional quality with an instrument, i.e. legal origin, that cannot be affected by the pattern of trade. However, in the present analysis, the country characteristics in the interaction terms of interest are such, that they are unlikely to be affected by the pattern of offshoring, with the exception of IT infrastructure.

enables the cheaper transmission of ever more data (e.g. Blinder 2007). In contrast, some evidence suggests that the task content of service occupations has become more complex over time (e.g. Spitz-Oener 2006). The present analysis shows that this type of service in particular relies on understanding and trust, which for the United States are enhanced by its past colonial ties, and a membership in NAFTA. These findings shed doubt on the prediction that the spread of ICTs is automatically leading to an increasingly flat world for trade flows of services.

Data availability limits the scope of the required disaggregated analysis to the United States. Because we can expect bilateral trade datasets to become increasingly available at the level of detailed industries, future works should try to extend the present analysis to a broader set of offshoring countries.

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Appendix A: Offshoring proxy

The share of offshoring in gross production, is calculated based on the following equation:

$$offshare2_{sct} = \left[\frac{SP_{st}}{TSO_{st} + SI_{st} - SE_{st}}\right] \frac{SI_{sct}}{TSO_{st}} \tag{5}$$

The information on bilateral U.S. services imports comes from BEA bilateral trade data. In Table 5 of the *Detailed statistics for cross-border trade* the BEA provides information on *telecommunications, financial services* and *insurance services.* In Table 7 the BEA offers information by trading partner at the level of *legal services, computer and information services, management, consulting, and public relations* as well as *other business, professional, and technical services.* The remaining information needed to estimate these equations comes from BEA input-output tables (The Use of Commodities by Industries before Redefinitions (1997 to 2009)). Following the National Academy of Public Administration (2006, p.62), the ratio of intermediate uses to total domestic supply per service category is calculated as follows. On the one hand, to calculate total domestic supply per service category, Service Imports (SI) are added on to Total Service Output (TSO) because they enhance domestic availability of a certain service. On the other hand, domestic availability decreases if the service is exported or stored so that Exports (SE) have to be subtracted.

BEA bilateral trade data offer information on U.S. imports of other private services. The following list helps to illustrate the structure of the service classification in official U.S. statistics (see Koncz and Flatness 2008).

- Government services
- Private services
  - Travel Passenger fares
  - Other transportation
  - Royalties and license fees
  - Other private services
    - Education
    - **Financial services**
    - **Insurance services**
    - **Telecommunications**
    - Business, professional, and technical services
      - **Computer and information services**
      - **Management and consulting services**
      - Research and development and testing services
      - **Legal services**
      - **Other services**

For the period 2006 to 2009, data for affiliated as well as unaffiliated bilateral trade is available for the following 12 subcategories of other private services. Education includes payments of U.S. students studying abroad and excludes payments for distance-learning. These payments are included in training services (see Koncz and Flatness 2008). Hence, I will exclude this category because it does not measure service offshoring (for a similar argument see Amiti and Wei 2006).

Other (private) Services consist mainly of copyright payments for foreign motion pictures and television programs (see Koncz and Flatness 2008, p.20) Business, professional, and technical services can again be classified into nine different subcategories. Unfortunately, input-output tables provide information for the components of the category business, professional, and technical services only at a more aggregate level than bilateral trade data. As a result, within business, professional, and technical services my analysis is restricted to six service subcategories.[51] Activities within the two subcategories, construction, architectural, and engineering services as well as installation, maintenance and repair of equipment, need to be performed in a fixed location. As a result, I classify them as non-tradable and exclude them. The remaining subcategories include

[51] Input-output tables offer no information on the following subcategories: industrial engineering; research, development and testing services; and advertising.

computer and information services, legal services, management, consulting and public relations as well as other business, professional, and technical services.

Traded services in bilateral trade data are classified according to commodity basis, with commodity groups approximating North American Industry Classification System (NAICS) categories. In input-output tables commodities are classified according to so-called input-output codes. The BEA offers a concordance list between these codes and the industry classifications, according to the six-digit 2002 NAICS. As a result, information on offshored services from both data sources can be converted to a common classification, i.e. NAICS.

The concordance between commodity group titles and six-digit 2002 NAICS codes has been done according to information provided in *Table 7* of the BEA *Detailed statistics for cross-border trade* in combination with information on the content of industries according to the NAICS classification. The concordance between input-output codes and NAICS codes has been done according to the list provided in BEA input-output tables. The results are displayed in table 3 and table 4 lists the destination countries of U.S. service offshoring between 2006 and 2009.

Table 3: Concordance between BEA commodity codes, input-output codes and NAICS codes

Commodity industry	**Input-output codes**	**2002 NAICS codes**
Financial services	521C1, 523, 525	522000, 523000, 525000
Insurance services	524	524000
Telecommunications	513	517000
Computer and information services	5415, 514	541500
Management, consulting and public relations	55	551100
Legal services	5411	541100
Other (business, professional and technical) services	5412OP	541900

Table 4: U.S. service offshoring destinations

Argentina	Germany	Malaysia	Spain
Australia	Hong Kong SAR, China	Mexico	Sweden
Belgium	India	Netherlands	Switzerland
Bermuda	Indonesia	New Zealand	Thailand
Brazil	Ireland	Norway	United Kingdom
Canada	Israel	Philippines	Venezuela, RB
Chile	Italy	Saudi Arabia	
China	Japan	Singapore	
France	Korea, Rep.	South Africa	

Appendix B: Offshorability indices

The 2000 SOC system[52] distinguishes between 840 detailed occupations according to their occupational definition. To facilitate classification, detailed occupations with similar job duties, and in some cases skills, education, and/or training, are grouped together in 461 broad occupations, 97 minor groups, and 23 major groups. Service occupations include the major groups 11, 13, 15 to 29, 31 to 39, 41, 43, 49 and 53. For further information see the Bureau of Labor Statistics webpage. Several, not clearly defined terms are used in the context of material and service offshoring.[53] In this paper, the notion *service occupations* will be used for service-providing occupations *regardless of the industry* they are performed in. Of all service occupations, Moncarz et al. (2008) classified the following major groups entirely as non-tradable: community and social services occupations (SOC 21-0000); food preparation and serving related occupations (SOC 35-000); building and grounds cleaning and maintenance occupations (SOC 37-0000); personal care and service occupations (SOC 39-0000); and transportation and material moving occupations (SOC 53-0000).

Table 5 exemplarily illustrates the information on occupational-level offshorability provided in Moncarz et al. (2008) for the major group management occupations:

[52] A first SOC Manual was published in 1977 with revisions in 1980, 2000 and 2010. For more information on the history of occupational data classifications in the U.S., see Bureau of Labor Statistics (2001, p.105ff.).

[53] One example is an estimate conducted by McCarthy (2002) for Forrester Research. The results predict 3.3 million U.S. service-industry occupations to be offshored by 2015. However, in the further details it becomes clear, that service occupations in general, existing in manufacturing as well as in service industries, were considered.

Table 5: Offshoring susceptibility score

SOC code	Occupation title	Offshoring susceptibility score Moncarz et al. (2008)
11-0000	Management occupations	
11-3041	Compensation and benefits managers	9
11-3031	Financial managers	7
11-3042	Training and development managers	7
11-1011	Chief executives	6
10-1021	General and operations managers	6
11-3011	Administrative services managers	6
11-3021	Computer and information systems	6
11-2011	Advertising and promotions managers	5
11-2021	Marketing managers	5
11-2022	Sales managers	5
11-2031	Public relations managers	5
11-9041	Engineering managers	5
11-9121	Natural science managers	5

Source: Moncarz et al. (2008)

Of all service occupations, Moncarz et al. (2008) classified the following major groups entirely as non-tradable: community and social services occupations (SOC 21-0000); food preparation and serving related occupations (SOC 35-000); building and grounds cleaning and maintenance occupations (SOC 37-0000); personal care and service occupations (SOC 39-0000); and transportation and material moving occupations (SOC 53-0000). Table 6 reports the correlations between the measure of coordination requirements and skill intensities of production. As shown, the measure of coordination requirements is correlated with skill intensity. Industries that require most coordination prerequisites tend to be less skill intensive.

Table 6: Correlation coefficients between industry-level characteristics

	Moncarz et al.
Skill intensity	-0.7202

Appendix C: Additional data

GDP (current U.S. dollars) and population for all countries are provided by the World Development Indicators database. Average years of tertiary schooling are provided by theBarro-Lee database on educational attainment. Educational information at the occupational-level is taken from Moncarz et al. (2008) and then aggregated up to the industry level in the way described in 3.2 for the offshorability proxy. Geographic distance is most frequently measured between the economic centers of countries, with the centers assumed to be the capitals, this is the so-called great circle distance. A first obvious problem is the fact that proxying the economic center with the capital may be more appropriate for smaller countries than for large ones, including the U.S. The U.S. has several different major cities, widely apart from each other, each specialized in different services (see e.g. Bussière and Schnatz 2006). Hence, I follow e.g. Kandilov and Grennes (2007) and additionally use the weighted distance measure. Both distance measures are provided by theCEPII database . Time zone differences are calculated in hours separating the countries' capitals, varying from 0 to 12. Information on time zones was obtained from Wikipedia and from the World clock. I followed Head et al. (2009) and calculated time zone differences by employing $\min\{|h_{US} - h_c|, 24 - |h_{US} - h_c|\}$. Based on information provided by the ethnologue-based version of common language, I created a dummy variable that takes the value of one if at least nine percent of the population in the destination country speak English. A dummy which indicates whether English is an official language in the destination countries might not provide a very good proxy for the existence of English skills in the relevant business circles. English is a common second language in many countries, e.g. in educational and business environments. For instance, English is the standard in the provision of technology related services (e.g. Rishi and Saxena 2005, p.8). The dummy for a common legal system takes the value of one if the destination country is – like the U.S. - classified as having UK legal origins. Information on this is taken from Andrei Shleifer's database. Moreover, I control for the quality of legal institutions in the destination country by employing information on the rule of law from Kaufmann et al. (2009). I transform the original variable so that it only takes on non-negative values. NAFTA membership is indicated by a dummy variable taking the value of one if the country is a member, i.e. Canada and Mexico. I follow e.g. Kandilov and Grennes (2007) and Head et al. (2009) and employ information on past colonial ties as a proxy for cultural similarity. This information comes again from the CEPII bilateral database. Information on variables for internet users as a fraction of the population, personal computers as a fraction of the population as well as secure servers per 10,000 people, come again from theWorld Development Indicators database.

Table 7 shows the summary statistics for these country-level variables. All variables have the expected range. Table 8 shows the correlation coefficients between country-level variables. The correlation between some explanatory variables, i.e. the quality of legal institutions and availability of the internet, is surprisingly high (0.6171).

Table 7: Country-level characteristics, summary statistics

Variable	Observations	Mean	Standard Deviation	Min	Max
Colonial past	5124	.0327869	.1780957	0	1
Common language	5124	.420765	.4937301	0	1
log(Distance)	5124	8.934286	.5365834	6.306995	9.691551
log(GDP per capita)	4928	8.278473	1.596703	4.794486	11.67806
Internet penetration	4795	147.8556	329.373	.0127152	3229.814
Legal origin UK	5124	.3224044	.4674424	0	1
NAFTA	5124	.010929	.103979	0	1
Rule of law	5096	.5637054	.2120641	1337076	.9999999
Time zone difference	5124	5.68306	3.282677	0	12
Skill endowment	3892	.3780683	.3182467	.0064	1.5562

Table 8: Correlation coefficients between country-level characteristics

	Colonial past	Common language	log(Distance)	log(GDP per capita)	Internet penetration	Legal origin UK	NAFTA	Rule of law	Skill endowment
Common language	0.1135	1							
log(Distance)	-0.0244	-0.2061	1						
log(GDP per capita)	0.1317	-0.0896	-0.2432	1					
Internet penetration	0.0609	-0.0255	-0.2222	0.6139	1				
Legal origin UK	-0.0437	0.3774	0.2178	-0.1058	0.0215	1			
NAFTA	-0.0210	0.1495	-0.4295	0.1101	0.1317	0.0478	1		
Rule of law	0.1462	-0.0416	-0.1053	0.8138	0.7175	0.0577	0.0735	1	
Skill endowment	0.2048	-0.0280	-0.2239	0.6455	0.5235	-0.1265	0.1969	0.5458	1
Time zone difference	0.0820	-0.3771	0.7233	-0.0325	0.0157	0.1069	-0.2084	0.1035	0.0856

Appendix D: Additional regression results

Table 10 presents the results for zero-inflated Poisson regressions that include different regressors. Column (1) is the specification shown in column (2) of table 2. Column (4) is identical to the preferred specification shown in column (3) of table 2. Different tests confirm that favoring this last model is appropriate.

To decide which variables to include in the model, I perform the Wald test. The Wald test shows that I cannot reject $H_0 : \beta = 0$ for the following variables - -internet penetration, - time zone differences, - common legal origin, - rule of law, and - common language, both separately and interacted with the coordination requirements, because $p > 0.05$. However, based on economic reasoning, I keep the interaction terms with time zone differences and common language because the interaction term with distance could otherwise be biased. As Kandilov and Grennes (2007) have shown distance is a proxy for time zone differences and linguistic differences. Time zone differences and geographic distance are accordingly highly correlated (0.7233; see table 8 in appendix C).

The Akaike information criterion (AIC) and the Bayesian information criterion (BIC) can be used to select among several (nested and non-nested) models. Both criteria are based on the log likelihood of the model and introduce penalties for adding parameters to the model, which can increase the log likelihood. Stata calculates them as follows:

$$AIC = -2 \ln L + 2P_k$$

$$BIC = -2 \ln L + P_k \ln N$$

where $\ln L$ is the log likelihood of the model and $2P_k$ and $P_k \ln N$ are the penalties for the model size. Note that the BIC penalizes model size stronger. Because a larger log likelihood is preferred, the model with a smaller AIC and BIC is favored, in particular the second model is favored when $BIC_1 - BIC_2 > 0$ (see Long and Freese 2006, p.112f.; Cameron and Trivedi 2010, p.359f.). Raftery (1996) suggests the following guidelines for assessing the difference in the BICs from different models:

Table 9: BIC, Strength of evidence

Difference	Evidence
0-2	Weak
2-6	Positive
6-10	Strong
>10	Very strong

Source: Long and Freese (2006, p.113)

In the present analysis, there is at least strong evidence in favor of the last specification (column (4)) in comparison with every other specification.

Table 10: Zero-inflated Poisson regression

	(1) ZIP	(2) ZIP	(3) ZIP	(4) ZIP
Offshorability score	-25.88	-25.86	-25.64	-33.06*
	(16.91)	(16.86)	(15.90)	(15.96)
Internet penetration	-0.000185			
*offshorability score	(0.00136)			
Common legal origin	-0.431	-0.434		
*offshorability score	(0.797)	(0.788)		
Rule of law	-2.149	-2.393	-2.587	
*offshorability score	(2.321)	(1.888)	(1.772)	
Time zone differences	-0.0521	-0.0482	-0.0528	-0.0910
*offshorability score	(0.309)	(0.306)	(0.297)	(0.290)
Common language	-0.911	-0.922	-1.203	-1.370
*offshorability score	(0.899)	(0.874)	(1.120)	(1.085)
colonial past	2.043*	2.072*	2.169*	2.343*
*offshorability score	(0.975)	(0.906)	(0.928)	(0.959)
NAFTA	9.796*	9.825*	9.731*	11.06**
*offshorability score	(4.482)	(4.419)	(4.201)	(4.240)
log(geographic distance)	3.090	3.098	3.085	3.703
*offshorability score	(2.113)	(2.105)	(1.998)	(1.986)
Skill intensity	1.234	1.216	1.255	1.047
	(1.348)	(1.295)	(1.324)	(1.309)
Skill endowment	0.0596	0.0409	0.0766	-0.0873
	(1.087)	(1.070)	(1.116)	(1.100)
*skill intensity	-1.063	-1.037	-1.087	-0.784
	(1.599)	(1.517)	(1.554)	(1.425)
log(GDP per capita)	-0.153	-0.152	-0.141	-0.160
	(0.619)	(0.618)	(0.609)	(0.606)
Fixed effects	Year	Year	Year	Year

Table 10: continued

	(1) ZIP	(2) ZIP	(3) ZIP	(4) ZIP
Observations	3724	3724	3724	3724
Log pseudolikelihood	-4.657717	-4.657764	-4.658309	-4.661246
AIC	109.3	105.3	107.3	103.3
BIC	420.4	404.0	412.2	395.8

Columns (1) to (4): clustered standard errors at the country level in parentheses;
* significant at 10%; ** significant at 5%; *** significant at 1%

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