Special Features

A The euro and the geography of the foreign exchange market

By Arnaud Mehl

The United Kingdom's decision to withdraw from membership of the European Union has prompted discussions as to whether a share of the financial market transactions in euro conducted in the United Kingdom, notably in the City of London, would be relocated to the euro area. This special feature aims to shed light on the issue by considering locations for trading in euro using the global foreign exchange market as a case study. The aim here is therefore not to discuss the location of financial centres and competitive advantages of financial centres in general; rather it is to focus on only one aspect of this issue. In so doing, this special feature examines key stylised facts on locations, as well as some theoretical determinants and empirical evidence about their respective importance. This special feature shows that the bulk of foreign exchange transactions in euro are initiated outside the euro area in a few large financial centres, notably the City of London, whose importance as a trading venue for the euro has grown since the turn of the millennium. This suggests that trading location depends on certain spatial frictions, such as distance, domestic market liquidity and restrictions on capital flows. This special feature provides evidence that the frictions matter significantly, but that their impact has been altered by technological change and the advent of electronic trading. In particular, estimates suggest that technology dampens the impact of spatial frictions by up to 80% and has economically important implications for the distribution of foreign exchange transactions across the major financial centres.

Key stylised facts on the global location of foreign exchange trading in the euro

Evidence on the location of foreign exchange trading is available from the survey of foreign exchange market activity coordinated by the Bank for International Settlements (BIS). This survey has been conducted every three years since 1989. It provides the most comprehensive and consistent information on transactions in the foreign exchange market.

The BIS defines foreign exchange turnover as the daily average of the notional amount (in US dollar equivalents) of all transactions struck in April of the year of the survey. Dealers report their transactions with other reporting dealers, financial

institutions and non-financial customers.[29] Instruments covered include spot transactions, outright and non-deliverable forwards, swaps and options. The BIS adjusts data for both local and cross-border double-counting.[30]

Foreign exchange turnover is allocated across countries according to the location of the initiating sales desk.[31] The trading desk is used to determine the location of a deal when no sales desk is involved. Discussions with foreign exchange dealers suggest that banks often aggregate and net their positions in the same location as where they trade. In other words, there are no major differences between sales and trading desks in most cases. But the distinction might be more important in the case of smaller financial centres where the sales desk might remain local, but the trading desk might be in a larger centre, such as London, New York or Tokyo. Moreover, to account for the growing use of electronic execution methods, the triennial survey of April 2016 used electronic platforms' sales contacts, who service the client (or the trading desk or the electronic matching engine), to determine the location of a deal when no sales desk was involved.

The bulk of foreign exchange transactions in euro are initiated outside the euro area, notably in the City of London. The 2016 triennial survey suggests that 84% of transactions in euro are initiated outside the euro area (see **Chart 19)**. Of the remainder, around a half are initiated in France and Germany. The fact that most transactions involving the euro are initiated offshore in financial centres located outside the euro area is a feature shared with other currencies. Most transactions in US dollars or Japanese yen and many other currencies, for instance, are initiated outside their respective jurisdiction of issuance (see **Chart 20**).[32] The fact that foreign exchange trading in euro is so concentrated in financial centres outside the euro area contributes to explaining why cross-border capital flow and the euro's exchange rate may be poorly correlated in the short to medium term.

The largest share (43%) of foreign transactions involving the euro is initiated in the United Kingdom, which demonstrates the City of London's role as the world's largest foreign exchange trading venue. The United States comes a distant second with a 19% share, reflecting New York's role for transaction of all types and Chicago's,

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29 Each transaction is recorded once, and offsetting contracts are not netted. There is no distinction between sales and purchases. Direct cross-currency transactions (e.g. pounds sterling for Swiss francs) are counted as single transactions. Transactions that use a vehicle currency (e.g. the US dollar) are counted as two separate transactions.

30 The former are referred to as data in "net-gross" terms and the latter as data in "net-net" terms. For instance, local inter-dealer transactions in Germany are halved to obtain the correct turnover for Germany. As another example, transactions between a reporting dealer located in the United Kingdom and a reporting dealer located in France are halved to obtain the correct estimate of global turnover.

31 For example, when an employee of a savings bank in Berlin asks his or her foreign exchange dealer at Deutsche Bank in Frankfurt to buy JPY 50 million against euro, this transaction will be recorded as having taken place in Germany, because the sales desk is in Germany. Actual trading could take place elsewhere, for example traders at Deutsche Bank in London. The nationality of the reporting dealer is not relevant in this context. For example, when UBS in Frankfurt reports trades to the Deutsche Bundesbank, these transactions are allocated to Germany.

32 That the US dollar and the Japanese yen are widely traded in financial centres outside the US and Japan, respectively, reflects inter alia the US dollar's vehicle role in the foreign exchange market and the yen's role as a funding currency in carry trade strategies. Several emerging market currencies are also widely traded offshore; for further details see e.g. McCauley, R. and Scatigna, M. (2011), "Foreign exchange trading in emerging currencies: more financial, more offshore", *BIS Quarterly Review,* March, pp. 67-75.

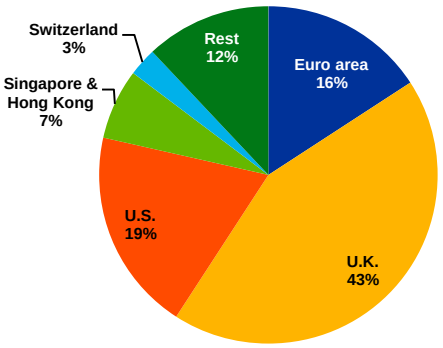
notably for futures contracts. Asian financial centres, such as Japan (Tokyo), Hong Kong and Singapore, account for much smaller shares – in the order of 3-4% each. The share of Switzerland (Zurich) is of a similar magnitude. Liquidity of the foreign exchange market in euros in China is low, with 0.3% of global turnover, which suggests that onshore trading of renminbi mainly takes place against the US dollar.

Chart 19

The bulk of foreign exchange transactions in euros are initiated outside the euro area, notably in the City of London

Share of selected countries in global foreign exchange transactions in euros, 2016

(percentages)



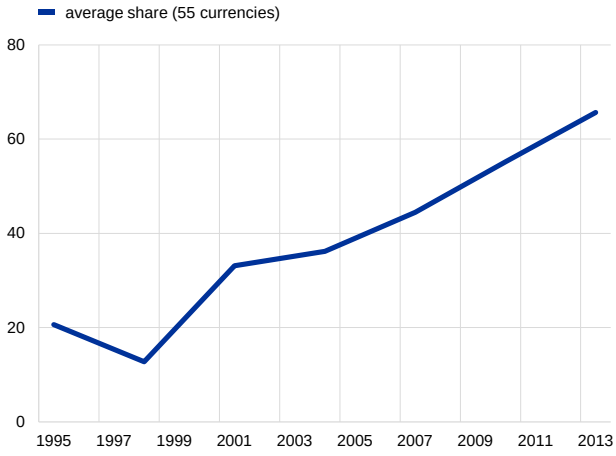
Sources: BIS and ECB staff calculations.
Note: The data include spot transactions, outright forwards, foreign exchange swaps, currency swaps, options and other products. They are adjusted for local inter-dealer double-counting and may differ slightly from national survey data owing to differences in aggregation procedures and rounding.

Chart 20

Most transactions in other currencies are also initiated outside their respective jurisdiction of issuance

Share of foreign currency trading occurring offshore, 1995-2013

(percentages)



Sources: BIS and ECB staff calculations.
Note: See Chart 19. The average share reported is based on panel data available for 55 currencies. Offshore trading means here that transactions are undertaken outside the country of issuance of the currencies in question.

The importance of the City of London for foreign exchange transactions in euro is a long-standing phenomenon.[33] The BIS data further suggest that the role of the City of London as a trading venue for the euro has grown steadily in the past 15 years. Since 2001 the share of the United Kingdom in global foreign exchange transactions involving the euro has increased by almost 10 percentage points (see **Chart 21**).[34] The importance of the euro area in this specific activity has weakened with its share declining by about 11 percentage points. The share of the United States has remained broadly unchanged, hovering at around 15%.

[33] See the 2003 edition of the *International role of the euro* report for an earlier analysis.

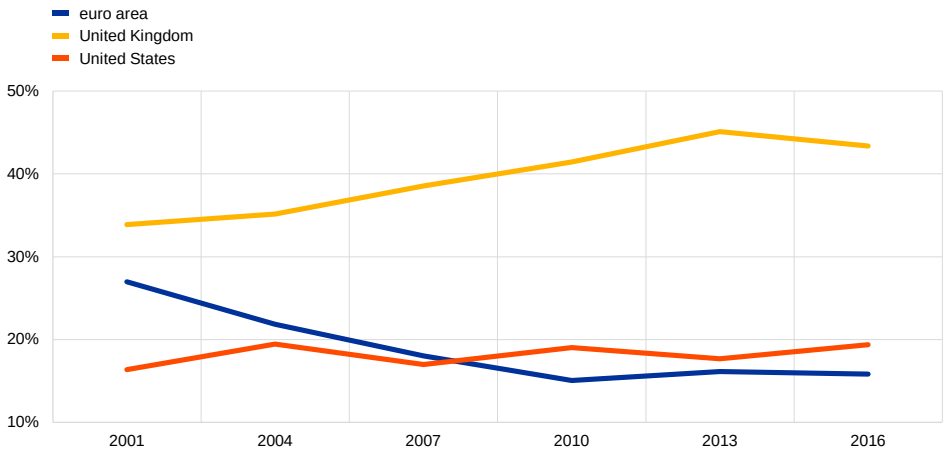
[34] 2001 was the year when the BIS conducted its first triennial survey following the creation of the euro.

Chart 21

Since 2001 the share of the United Kingdom in global foreign exchange transactions involving the euro has increased by almost 10 percentage points

Evolution of the share of selected countries in global foreign exchange transactions in euro, 2001-16

(percentages)



Sources: BIS and ECB staff calculations.
Note: See Chart 19.

Theoretical determinants of the location of foreign exchange trading

The fact that the location of foreign exchange trading in euro is not distributed uniformly across space, but is concentrated in a few large financial centres suggests that the location depends largely on certain spatial frictions.

One such friction is distance. One interpretation of the effect of distance is the fact that it gives rise to information asymmetries. Other things being equal, transactions tend to take place where information about the currency or currencies being traded is most easily obtained, which depends on distance, among other factors. In particular, the "local information" hypothesis posits that traders outside the country of issuance of a particular unit face an information disadvantage and trade less profitably because of culture, language and distance.[35] Put differently, trading of a currency is most likely to remain local if large financial centres are distant from its country of issuance.

Another spatial friction is domestic market liquidity. More liquid markets allow transactions to be undertaken at lower cost. Bid-ask spreads are narrower, and traders can buy and sell larger blocks without moving prices. Where local markets are small and illiquid, the appeal of large financial centres known for their depth and liquidity will be particularly strong. Conversely, where local markets are liquid, they

[35] See the discussion in Hau, H. (2001), "Location matters: an examination of trading profits", *Journal of Finance* 56, pp. 1959-1983, in relation to the equity market.

are likely to capture a larger share of trades. This can also be rationalised by referring to models in which concentration of activity in a particular location has positive feedback effects on the advantages of further concentrating activity in that location.[36] In other words, greater market liquidity may lead to self-reinforcing effects in the concentration of suppliers of intermediate goods or specialised services, such as legal, information technology and accounting services, as well as in the availability of skilled and talented staff, which are important for foreign exchange trading.

A third set of frictions are restrictions on capital flows. Milton Friedman famously argued that taxing financial transactions onshore provides incentives for business to migrate offshore (where capital controls are equivalent in this context to a tax on purchases and sales of a foreign currency).[37] In some cases offshore markets have developed through trading in non-deliverable forward contracts, which enable investors to actively trade claims indexed to a currency despite controls maintained by the issuing country that limit their access to the underlying currency itself.[38]

An essential feature of the foreign exchange market is that it has been transformed by the advent of electronic broking and trading. Electronic trading appeared in the early 1990s and has developed ever since, owing to the availability of increasingly cheap and efficient information and communications technology. Electronic trading now dominates the foreign exchange market, with a share above 50% for all customer segments and availability for instruments and investors the world over. Two trading platforms, Electronic Broking Services (EBS) and Thomson Reuters, traditionally dominate the market, although transactions do take place on other platforms as well.[39] A widespread view is that standard geographical factors such as location and distance should no longer matter in such a ubiquitous, round-the-clock electronic foreign exchange marketplace.

Assessing the impact of technology on foreign exchange trading is not straightforward, however, because causality runs in both directions. Investments in technology can affect the geographical distribution of economic activity, but changes in the geographical distribution of economic activity also provide an incentive for investments in technology. There is, however, one specific source of exogenous change and spatial variability which can be exploited to tease out the effect of technology on the location of foreign exchange trading. This is the laying of submarine fibre-optic cables starting in the late 1980s. The majority of international communications traffic is carried by submarine cables; the remainder is carried by satellite. Cables are also the principal conduit for data transmission for the internet,

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36 See the models and arguments of Krugman, P. and Venables, A. (1996), "Integration, specialization, and adjustment", *European Economic Review* 40, pp. 959-967.

37 Friedman's example illustrating the power of this hypothesis was the development of the Eurodollar market in London as a response to the adoption by the US of Regulation Q in the 1960s (see Friedman, Milton (1969), "The euro-dollar market: some first principles", *Selected Papers*, No 34, Graduate School of Business, University of Chicago).

38 See McCauley, Shu and Ma (2014).

39 Electronic trading also takes place on multibank electronic communication networks (such as Currenex, Hotspot FX and FXall).

which is why they are often referred to as the “internet backbone”. They have transformed the foreign exchange market by reducing latency and considerably increasing bandwidth, which is essential in a world where data processing needs are growing exponentially and high-frequency trading accounts for a rapidly growing share of foreign exchange trading.[40] Importantly, the existence of a cable link between two countries at a certain point in time can be regarded as exogenous to foreign exchange trading for an array of reasons.[41] Also, because cables were laid and came into use at different points in time, the network of active submarine cables provides a source of exogenous changes that vary over both space and time, which in turn allows us to identify causality.

This identification capitalises on the special role played by three large financial centres in electronic foreign exchange trading, namely London, New York and Tokyo. It is in these cities that the matching servers of EBS and Thomson Reuters, the leading platforms for electronic broking and trading, have been located since the early 1990s. In Equation 1 below, the effect of technology on spatial frictions is measured with an interactive dummy variable that equals 1 if country *i* is cable-connected to either the United Kingdom (for London), the United States (for New York) or Japan (for Tokyo) at time *t* and 0 otherwise. Connections via submarine fibre-optic cable reduce latency and increase bandwidth.

Theory suggests that the effect of technology on the share of trading occurring offshore is ambiguous. Cable connections help reduce the transportation costs of buy and sell orders involving counterparties in different locations. They help cut the costs of electronic transactions, of aggregating and matching buy and sell orders, and of processing information and data more generally. All else being equal, this should help to attenuate standard spatial frictions such as distance, domestic market liquidity and capital controls which otherwise prevent transactions from moving to large financial centres (i.e. offshore), as the standard “home market effect” suggests.[42] We therefore expect the estimated coefficients on the interactive dummy variables to be positive. All else is not equal, however. The effect could go in the opposite direction, because cable connections between local markets and matching servers in the major financial centres lower the fixed costs of trading currencies locally by easing access to financial information and increasing bandwidth. They enhance the competitiveness of local sales desks and help them keep or repatriate foreign exchange transactions domestically (i.e. onshore). Here we expect the coefficient on the direct effect of technology to be

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40 Latency refers to the speed in milliseconds at which trading venues acknowledge an order after the order in question was sent. Bandwidth refers to the amount of data that can flow through a cable per unit of time.

41 First, the layout of the submarine cable network is heavily influenced by geographical constraints related to the seabed topography. Second, the network is mapped over the earlier telegraph and coaxial networks of the nineteenth century and of the 1950s and 1960s, respectively. Third, the layout of submarine fibre-optic cables hinges upon safety and strategic considerations. Fourth, the cables were initially laid for general telecommunication needs, not for purposes related to the foreign exchange market. Finally, installation and maintenance costs of submarine fibre-optic cables are so high that they are usually owned by large telecommunication firm consortiums, not by financial institutions. See Eichengreen, Lafarguette and Mehl (2016) for further details and explanations.

42 See Krugman, P. (1980), “Scale economies, product differentiation, and the pattern of trade”, *American Economic Review,* Vol. 70, pp. 950-959 for more details.

negative. Which of the two effects dominates is an empirical question to which we now turn.

Empirical estimates of the determinants of the location of foreign exchange trading

These theoretical predictions are compared with the data in a recent study[43], which estimates the following equation:

$$y_{i,t} = \beta_1 Time\ Zone\ Distance_i + \beta_2 Domestic\ Market\ Liquidity_{i,t} + \beta_3 Capital\ Controls_{i,t} + \boldsymbol{\beta'_4}\,\mathbf{X} + \vartheta_i + \lambda_t + \varepsilon_{i,t} \quad (1)$$

where *i* and *t* denote currency and time; *y* is the share of trading occurring offshore for the unit issued by country *i* in year *t* ; ϑ_i are random effects; and λ_t are time-fixed effects.[44] Data for the dependent variable were provided by BIS staff for a sample of 55 currencies between 1995 and 2013. Distance is measured by the time zones between the country issuing currency *i* and either London, New York or Tokyo (whichever is closest).[45] Domestic market liquidity is measured by the volume of transactions in foreign currencies in country *i* in year *t* (transactions in domestic currencies are excluded from the domestic market liquidity metric to avoid spurious correlations). Restrictions on capital flows are measured by the time-varying indices of de jure capital account openness constructed by Fernandez et al. (2015). In sensitivity tests, control variables such as trade openness, financial openness, exchange rate flexibility and dollar-funded carry trades are included in Equation 1.

Table 2 reports estimates of Equation 1. **They suggest that standard spatial frictions such as distance, domestic market liquidity and, to a lesser extent, capital controls have a significant impact on the geography of the foreign exchange market.**

[43] Eichengreen, B., Lafarguette, R. and Mehl, A. (2016), "Cables, sharks and servers: technology and the geography of the foreign exchange market", *NBER Working Paper*, No 21884, January.

[44] The share of trading occurring offshore is defined as the ratio of transactions in currency *i* at time *t* occurring outside the jurisdiction of issuance of currency *i* (e.g. the euro area for the euro, Japan for the yen, India for the rupee, etc.) relative to global transactions in currency *i* at time *t*.

[45] London, New York and Tokyo are taken as reference points because they are the largest foreign exchange trading venues and because they host matching servers of EBS and Reuters (see above). Hour distance is preferable to physical distance since traders in adjoining time zones will receive news more or less simultaneously, and since it allows us to take into account differences in liquidity arising from non-overlapping trading hours, which matter for computer-run algorithmic or automated trading strategies seeking to transact with sleeping agents. This choice is consequential: Johannesburg, for example, is more than 13,000 kilometres away from London but only one time zone ahead.

Table 2

Empirical estimates of the determinants of the location of foreign exchange trading

	(1) Panel tobit	(2) Panel tobit	(3) Panel GLM	(4) Panel GLM	(5) Panel tobit	(6) Panel GLM
Time zone distance	-0.120*	-0.085+	-0.257	-0.384+	-0.463***	-1.443***
	(0.064)	(0.060)	(0.263)	(0.271)	(0.127)	(0.478)
Domestic market liquidity	-0.383***	-0.388***	-1.384***	-1.342***	-1.757**	-7.746***
	(0.093)	(0.095)	(0.391)	(0.201)	(0.818)	(2.115)
Capital controls	-0.109	-0.100	-0.502	-0.525	-0.289+	-1.358+
	(0.107)	(0.106)	(0.466)	(0.476)	(0.186)	(0.845)
Trade integration		-0.091		-0.249		
		(0.071)		(0.299)		
Financial integration		0.094+		0.240		
		(0.060)		(0.281)		
Flexible exchange rate regime		0.145**		0.765**		
		(0.056)		(0.341)		
Carry trades		-0.005**		-0.032		
		(0.002)		(0.045)		
Cables					-0.305***	-1.157**
					(0.114)	(0.518)
Cables × time zone distance					0.362***	1.320***
					(0.112)	(0.486)
Cables × domestic market liquidity					1.398*	6.380***
					(0.814)	(2.104)
Cables × capital controls					0.241+	0.833
					(0.189)	(0.892)
Constant	0.119	0.124	-1.331**	-1.150**	0.453***	-0.159
	(0.100)	(0.110)	(0.547)	(0.568)	(0.133)	(0.431)
Currency effects	YES	YES	YES	YES	YES	YES
Random effects	YES	YES	YES	YES	YES	YES
Observations	252	238	252	238	252	252

Source: Eichengreen, Lafarguette and Mehl (2016).
Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1, + p<0.2.

The estimated effect of information asymmetries on the share of trading offshore is negative and statistically significant, which is consistent with the "local information" hypothesis. The coefficient in column 1 suggests that each hour difference in time zone relative to the United States, the United Kingdom or Japan lowers the share of offshore trading of the currency issued by the country located in the time zone in question by 12 percentage points. The estimated effect of domestic market liquidity on offshore trading is also negative, as anticipated, and significant. The coefficient estimate in column 1 implies that the share of offshore trading of a currency issued by a country where the volume of local foreign exchange transactions is USD 250 billion larger (a large amount by today's standards) is about 10 percentage points lower.[46] The effects of capital controls are statistically insignificant, in contrast. This is at variance with Milton Friedman's hypothesis that capital controls (since they are

[46] USD 250 billion is close to the volume of offshore foreign exchange trading in Singapore or Zurich, for example, as of 2013. This result may reflect agglomeration effects arising in a self-perpetrating way, as in Krugman and Venables (1996).

equivalent to a tax) encourage foreign exchange transactions to migrate offshore. However, it may be that this result reflects omitted variable bias, in particular the effect of technology, as we show below. Furthermore, estimates controlling for trade integration, financial integration, the exchange rate regime and carry trades are broadly similar.[47]

The impact of technology on the standard spatial frictions is considered in the estimates with interacted effects reported in columns 5 and 6 of Table 2. The main findings for the standard determinants of the geography of foreign exchange trading remain broadly unchanged, with the estimated coefficients now being if anything larger in economic magnitude. In addition, the direct effect of connection to a submarine fibre-optic cable is negative and typically statistically significant. This implies that a cable connection makes it more likely that a country will be able to retain (or repatriate) trading in its currency at home, other things being equal, presumably because the costs of trading locally are lower.

But other things are not all equal in practice. The interacted effects of submarine fibre-optic connections are also statistically significant.[48] They go in the opposite direction to the direct effect of fibre optic connections. Overall, they suggest that the negative effect of distance or information asymmetries on the share of a currency traded offshore is smaller (in absolute value) in the presence of cable links. The negative effect of capital controls is again smaller (in absolute value). Thus, where the direct effect of a cable link to one of the three major centres is that a country may retain more transactions in its currency onshore, the indirect effect is the weakening of other factors (distance, local market liquidity, capital controls) which previously segmented markets and gave it a locational advantage.

Chart 22 provides evidence of the economic magnitude of these effects. It shows the predicted share of offshore foreign exchange trading in relation to the extent of information asymmetries (time zone differences) when other spatial frictions are set to zero, both with cable connections (the yellow line) and without (the blue line). For a country close to one of the financial centres, the main impact of the cable connection is direct: it allows the country to retain a larger share of trading in its currency (towards the left-hand side of the figure, the yellow line is below the blue line, indicating that a smaller share of transactions occur offshore in the presence of a cable).

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47 Carry trades are measured as the difference between the short-term local-currency interest rate in country *i* and in year *t* and the corresponding US interest rate. The coefficient on carry trades is negative and also significant, which suggests that high local interest rates relative to the United States encourage market participants to invest in local money markets and exchange funding in dollars or yen (or another low-interest rate unit) against local currency onshore to that end.

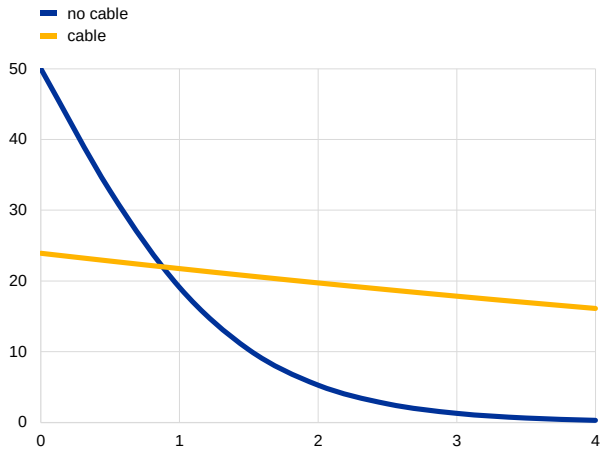
48 At the 20% level of confidence for capital controls using a panel tobit estimator, albeit not with a generalised linear model estimator.

Chart 22

For a country close to one of the financial centres, the main impact of the cable connection is direct

Impact of submarine fibre-optic cable connection – distance/information asymmetries

(y-axis: percentages; x-axis: hours)



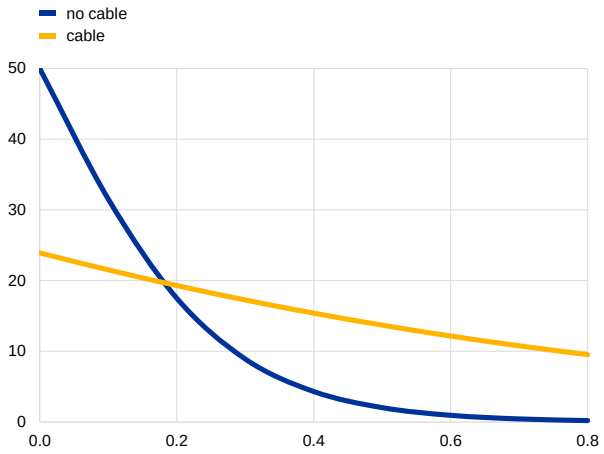
Source: Eichengreen, Lafarguette and Mehl (2016).
Note: Estimates based on column (6) of Table 1.

Chart 23

Attractions of deep and liquid domestic markets are lessened by cable connections

Impact of submarine fibre-optic cable connection – domestic market liquidity

(y-axis: percentages; x-axis: USD trillion)



Source: Eichengreen, Lafarguette and Mehl (2016).
Note: Estimates based on column (6) of Table 1.

Conversely, for a country far from one of the large financial centres, the main impact of the cable connection is indirect: it erodes the advantages of distance, causing the country to lose a larger share of trading in its currency to offshore markets (towards the right-hand scale of the figure, the yellow line is above the blue line, indicating that a larger share of transactions occur offshore). How large is the effect on average? Taking the ratio in percentage terms of the slopes of the two lines, obtained from the tobit estimates, suggests that the effect of distance in hours on the share of foreign exchange trading occurring offshore is almost 80% lower on average in countries connected to a submarine fibre-optic cable, relative to countries that are equally distant from a major financial centre but not connected. **Chart 23** shows how the attractions of deep and liquid domestic markets are also lessened by cable connections, which points to a similar conclusion.

Overall, cable connections increase the share traded offshore for the vast majority of currencies in the BIS sample, which suggests that the dampening effect of technology on spatial frictions tends to dominate in net terms. **Technology has economically important implications for the distribution of foreign exchange transactions across financial centres, as a result.** Undersea fibre-optic cables provide a competitive advantage to financial centres located near oceans, like Singapore, because they are directly connected to the internet backbone, at the expense of landlocked cities like Zurich. By one estimate, cable connections have boosted the share in global turnover of London, the world's largest trading venue, by as much as one-third.[49]

[49] See Eichengreen, Lafarguette and Mehl (2016) for details on the estimates.

These findings shed light on discussions triggered by Brexit as to whether foreign exchange trading will be moving away from London if the United Kingdom does leave the European Union. Because the United Kingdom is, for the time being, an EU Member State and fully open to capital flows in the sample considered here, and because there is no financial centre rivalling the City of London in importance, we should avoid considering the findings reported here as counterfactual estimates of what the City's share of global foreign exchange turnover would be in scenarios in which it would no longer have advantages linked to being part of the single European market. However, the findings are consistent with anecdotal evidence gleaned from market participants that London's trading cables and wider pull, combined with institutional inertia, mean that any shift to mainland Europe after Brexit would be gradual.[50]

[50] See, for example, press reports on an interview with one (New York-based) market participant who argues that because the "wires that make the trading of FX electronic are all in London", a "quick move from the UK to Europe" would be costly and "require infrastructure spending". See Faulconbridge, Guy (2015), "'Brexit' fears haunt London's roaring trade in euros", Reuters, available at http://www.reuters.com/article/2015/07/22/us-britain-eu-euro-insight-idUSKCN0PW13620150722 (accessed 12 August 2015).