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of Fintech collaboration: Scotland and Ireland

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THE OUTPUT AND PRODUCTIVITY BENEFITS OF FINTECH COLLABORATION: SCOTLAND AND IRELAND

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This paper is a thought piece on the impact of joint collaboration in fintech on output and productivity. It identifies a distinct fintech sector from both the Scottish and Irish financial and technology related industrial groupings and maps the largest employers amongst the fintech start ups. The multiplier effect of this subgrouping and the sectors productivity enhancing nature are used to forecast the job impact of such collaboration. Our analysis of the Scottish and Irish fintech sub-sector shows that joint collaboration in fintech will increase output and labour productivity, outpacing Scottish and Irish GDP growth and labour productivity. The key conclusion is that collaboration could be net positive for employment assuming no exogenous shocks caused by the new technology from other geographies.

KEYWORDS

Fintech, Scotland, Ireland, Financial employment, Collaboration,

Abbreviations: Fintech - Financial technology.

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1 | INTRODUCTION

The financial sector is important for the effective allocation of resources in both the Scottish and Irish economies. According to (Scott, 1951) there have been common elements in the financial system since the Middle Ages. There has also been a common cultural tradition that (Pittock, 2008) described as “Scottish and Irish Romanticism”. (Kidd, 1994) showed that this led to a shared “Gaelic antiquity and national identity”. This developed into what (Jackson, 2012) describes as an interlinked Unionist movement. That said, it is not the shared Gaelic language or social history but the shared common English language and legal tradition that we believe unite the financial markets. This paper takes these and combined with a mapping of fintech start-ups in both jurisdictions suggests how that common heritage can be leveraged by joint collaboration in the new and growing fintech field.

With the advent of digital technologies, the Internet and breakthroughs in secure protocols for money transfer, the efficiency of both the Scottish and Irish financial sectors is set to improve dramatically. In a conference paper for the Scottish and Irish Finance Initiative (Clarke and Broby, 2017) argue there are potential benefits in extending this common heritage in the field of Fintech. This would build on the parallels in economic and social development between the two nations identified by (Davine and Dickson, 1983) and presented to conference at Strathclyde University. (Clark and Broby, 2017) suggest this would be best achieved by leveraging the front office strengths of the financial sector in Edinburgh, the back office strength of Glasgow and the support service strength of Dublin. The authors highlight the proximity of the financial centers as a major advantage.

Ireland and Scotland have been called *Celtic tigers* by a number of commentators, including (Battel, 2003). Collaboration and the combination of joint strengths has upside potential for both nations and would reestablish the Celtic Tiger claims as far as fintech goes. We illustrate how this might be achieved.

2 | WHAT IS FINTECH?

In order to understand the impact on output and productivity it is first necessary to define fintech. It is the popular shorthand term for financial technology as applied to the digital transfer of assets. As payments are central to any economy, financial technology and the transfer of value between counter parties could be viewed as the core backbone of the banking system, be it in Scotland, Ireland or elsewhere. This is because the Internet changes the way such transfers can be processed.

As any digital financial asset can now potentially be settled over the Internet, the backbone of the financial system is set to change. This is a regime shift and important for the economies of both Scotland and Ireland to get right. The resulting impact on the business model of financial companies will be dramatic and extends to all traditional banking businesses such as insurance and asset management. Future digital money transfer innovation will impact both the existing banking businesses and new “challenger banks”. For this reason, we argue that joint co-operation on fintech products and research will lead to a first mover advantage and benefit the smaller financial markets in Dublin, Glasgow and Edinburgh (at the expense of larger centers such as London, Paris and Frankfurt).

We define fintech, more precisely, as ***financial technology employed in digital transactions, settlement, and clearing in a distributed environment***. There has been much debate, as detailed in (BIS, 2017), as to the implications of the so-called fintech revolution. There is little doubt that the net impact on jobs in the financial sector will be negative globally. This is because much of the automation that fintech brings will result in fewer employees being required in the middle and back office to work on payments, transfers and settlements. Despite this, the basic premise of this paper is that the fintech sector has the potential to contribute to economic growth and in job creation regionally.

There will be job losses in the larger financial centers and, in the less proactive smaller jurisdictions. That said, regional job gains can be achieved by developing new skill-sets such as programming and analytics. Obviously, many regional centers will also have job losses, the reason we advocate joint co-operation between Scotland and Ireland. The future is uncertain and co-operation diversifies the risks.

3 | COLLABORATIVE TECHNOLOGIES

At the core of fintech lies the technologies of blockchain, distributed ledgers, big data and mobile wallets. This is where co-operation should be considered. The first, blockchain, serves as an immutable ledger which allows transactions to take place in a decentralized manner. The second, distributed ledgers, allow this information to be stored throughout the Internet and the third, mobile wallets, allows portability. These innovations will create a whole host of new jobs in both markets, including start-ups focused on the processing of big data sourced from financial companies, the creation of challenger banks, an army of code writers and new roles in the audit of blockchains and development of, for example, distributed ledgers. Cooperation between Ireland and Scotland would facilitate these, including the development of associated software for mobile devices.

The areas impacted are across the board. In Scotland and Ireland they include money transfer and payments, regulation and compliance, investment and retail banking, insurance, mobile banking, and stock and share transactions. It is not surprising, therefore, that (Campenon, 2016) commented on the impact of fintech on financial services and predicted that financial markets will undergo profound changes. For securities-services providers, the pace of change will accelerate with increased consolidation, pervasive regulatory mandates, as well as greater technological innovation. As the future is unpredictable, in this sense, joint co-operation and collaboration reduces the risk and magnifies the reward.

Co-operation can be divided along business models and indeed we recommend a broad approach. In this respect, the Scottish and Irish fintech ecosystem are similar in concept to the “business to business” and “business to consumer” categories of Internet disruptors. The model reflects the literature on the potential for fintech to disintermediate.

The benefits of collaboration have been firmly established by academics, amongst others (Ahuja, 2000) and (Katz and Martin, 1997). The latter broke down collaboration into five variables, namely (1) *governance*, (2) *administration*, (3) *organizational autonomy*, (4) *mutuality*, and (5) *norms*. In respect of fintech companies, the first and second of these, *governance* and *administration*, are identified by us as weak drivers of fintech. We found that the third, *autonomy*, was a strong driver. The classifications of *mutuality* and that of *norms* were found by us to be areas areas that can improve by collaboration.

(Thomson and Perry, 2006) undertook a literature review on collaboration and distinguished between different approaches. They showed that inter-institutional and international collaboration need not necessarily involve inter-individual collaboration. They argued a dual approach is just a partial indicator of collaboration and that a more symmetrical approach is required. They highlighted “the undoubted benefits” of research collaboration.

Supporting our case that research collaboration is the best option, (Kim, 1986) pointed out that technology is the driver of fintech related productivity enhancements and hence should be the focus of collaboration. (Ryabova, 2015) demonstrated that incumbent financial institutions do acknowledge being threatened by fintech companies. These financial institutions typically represent the most significant part of banking assets. There is some evidence that the incumbents that have expressed concern about fintech competition are more likely to be involved in the fintech space.

Scotland and Ireland have concentrated traditional banking champions as well as a healthy fintech start up environments, supported by government policy. Our research shows that this can foster employment in shadow banking, data

analytics and application based periphery services. All these areas should be targeted by policy makers.

4 | FINTECH BUSINESS MODEL AND FINANCIAL INTERMEDIATION

Modeling the transformative nature of fintech is complicated because academics do not agree on what an appropriate banking business model is. This is why the relevant literature for fintech companies is subdivided between Internet and technology disruptors, value creation, competitive advantage, company performance and innovation. A good summary can be found in (Zott, Amit, and Massa, 2011) and these categories fit closely to those fintech startups identified in our mapping exercise.

In order to understand the impact of fintech, it is necessary to consider how economies use and transfer money. In this respect, the legacy payments system nets off money transfers in batches, typically twice a day. This is slow and cumbersome and gives rise to counter-party risk. Where larger sums are involved, banks use Real Time Gross Settlement (RTGS). This method requires short term liquidity, typically from the central bank. As such, it has an interest rate cost. The promise of fintech money transfers is that they can remove both of these inefficiencies.

Any mention of business model in this context should point out that the global financial crisis had a big impact on Ireland's financial sector, as explained in (Lane, 2012). According to (Bénétrix, 2015) Ireland has a history of risk taking in international collaboration (O'Farrell, 1995) showed that Irish companies had a greater overseas facing orientation (16 per cent of sales) than Scottish firms (4 per cent). The financial crisis, likewise, had an effect on Scotland, with Royal Bank of Scotland being rescued by the British government.

We illustrate the early developments in fintech in Scotland by reference to Royal Bank of Scotland. They have developed a model of innovation that is promoting the fintech agenda. After developing a global payment processing business, RBS entered fintech early in its insurance business through Direct Line, subsequently sold. The lessons learnt from its early Fintech experiments and subsequent divestments was that the bank had to do more to capitalise on technology. Recent developments such as the Internet, cheaper data storage combined with the 2008 financial crisis all contributed to the opportunity in fintech. As such, more recently, RBS is being far more proactive in respect of fintech.

We return to our focus on the use of a business model to describe how a firm does business, rather than value creation or capture. In this respect, we draw on (Timmers, 1998) definition of the business model as "an architecture of the product, service and information flows". This extends to including a description of the various stakeholders, their potential benefits and the firm's sources of revenue.

Research into business models has multiplied since the adoption and adaption of the Internet in corporate strategy and as such there is no clear fintech model. Some, such as (Amit and Zott, 2001), argue that it is the nature of the Internet itself that has driven this. Others, focus on changing demographics, emerging markets and/or expanding industries. Innovation in the business model can be difficult due to old human capital models that are normally driven by "siloe" business unit approaches. (Chesbrough, 2007)

As mentioned, it is widely believed that these breakthroughs will result in job losses as a result of the efficiency gains resulting from dis-intermediation. That said, the economies that are early adopters of fintech will gain employment in new areas and from establishing a competitive advantage over slower movers, hence our empirical analysis. Evidence of the point in respect of the value of cooperation was demonstrated by (Ginevičius, 2010). We applied this to the financial companies, establishing new job specifications.

There is widespread agreement that the fintech banking model is disruptive. (Samuelson, 1958) was the first to illustrate how money usage can be divided between generational usage and thereby making payments between them Pareto optimal. This model involves a central counterpart and is explained in detail by (Mills, 2006). A fascinating side of

the most talked about fintech technologies, blockchain and distributed ledgers, is that such central counterparts are not required in a world where liquidity can be matched instantly and securely over the Internet. As a bank derives income from payments, this represents a challenge to the traditional business model. Such payments without intermediaries were pioneered by (Nakamoto, 2008). This is where we believe collaboration in research should result in the largest employment impact on the upside.

The fintech business model has the potential to dis-intermediate the banks and once again this is why we believe collaboration is so important. In order to understand the magnitude of this threat, one has to consider the role of banks in the economy. At their most basic, they are engaged in lending and borrowing, facilitated by receiving deposits and extending credit. In a perfectly competitive economy, there would be no need for intermediaries. This can be illustrated by a simple economy with a single consumer, producer and financial intermediary and two periods of time, as per (Keiding, 2016), where the consumer has a weighting the good and wants to consume in both time periods. As such, he chooses a combination of weights, in order to maximize his utility under the budget constraint. This is depicted thus:

$$x_0 + b_c + s \leq \omega \quad (1)$$

$$(px)_1 \leq (1+r)b^c + (1+r_D)s + \pi^p + \pi^b \quad (2)$$

Where: b^c = loans taken by the consumer in period zero to paid back in period one,

s = savings in the form of bank deposits,

p = price,

r = Interest rate,

π^p = Profits of the producer,

π^b = Profits of the bank.

Using this condition, (Keiding, 2016) argue that “a bank only mimics the bond market, playing no role of its own, and is superfluous in the economy considered.” As a result of this, liquidity transformation becomes the central benefit of the banking system. This was earlier explored by (Diamond and Dybvig, 1983) who concluded that the choice of consumption therefore depends on the selection of institutions available, to which we would add fintech disruptors. Central banking representatives also acknowledge that changes in customer loyalties can affect the sources for bank funding and can even add to systematic risks (Carney, 2017). As such, collaborative research on the impact of fintech models on borrowing and lending will have societal implications.

5 | EMPLOYMENT

Our analysis of the impact on employment began with a job mapping. We identified SME’s in both Ireland and Scotland. This was provided by the development agencies and cross referenced to a linkedin employment map. Many of the companies classified as fintech were self-certified and on closer examination were not necessarily that sub classification. In the startup sector, fintech is broadly defined as the “re imagining of finance through technology”, and can be segregated into WealthTech, RegTech, InsurTech, digital banking, payments and CapTech (capital markets technology). However, for the purposes of this paper, we include those working in technology roles in the financial sector as whole, including

the development of proprietary technology by the likes of banks, insurers and asset managers and those integrating third party enterprise software into these established players.

The traditional employment in banks and insurance incumbents was even harder to classify. We identified the total number in the sector. We identified some seven per cent of that employment as being directly related to technology. The self-classification varied greatly from company to company. An insurance company employee just collecting data, for example, self-certified as fintech despite not using big data tools. We also found that certain sectors, such as asset management, were wary of classifying themselves as fintech. As a result, the numbers we ended up with were not as accurate as we had hoped. We estimate some 2,100 jobs could be said to be wholly or partly fintech related in Scotland and 4,200 in Ireland. We then proceeded to identify how much of this was start up related.

The starting point for the fintech start-ups was the LinkedIn headcounts. The official LinkedIn website of the company was identified in order to obtain the number of employees associated to the company worldwide. A filter was then applied to get a separate headcount only for Ireland/Scotland. We used ISEQ and Scottix constituents, representing leading listed companies in Irish and Scotland based on head office, to get an idea of prior growth in employment. For the fintech companies that we compared them to, we used further sources such as Crunchbase, Solocheck, and the company website to identify the office location. The fintech start up headcount in Ireland was 2699 and in Scotland was 391. This was 64 per cent of the fintech jobs in Ireland and 18.6 per cent in Scotland, the lower Scottish percentage being down to the location of JP Morgan's fintech hub Europe on Glasgow and RBS's head office in Edinburgh.

We reviewed our data using the UK and Irish IO tables. Unfortunately, these were last updated on data 1998-2013 missing much of the Fintech boom. These tables represent the economic accounts and relevant employment and income multipliers of each respective country. The IO system used is built up using double-entry book-keeping, a method which reconciles the income, output and expenditure of Gross Domestic Product (GDP). (Miller and Blair, 2009) detailed it as a model:

$$X = ((I - A))^{-1}Y \quad (3)$$

Where:

X = the vector of output in Irish and Scottish financial sectors,

I = the identity matrix,

A = the matrix that summarizes the economic structure of Irish and Scottish financial sectors,

Y = the matrix of final demand within the Irish and Scottish financial sectors,

$((I - A))^{-1}Y$ = the Leontief inverse matrix that allows the estimated increase in output in other sectors as a result of increased outputs in the financial sector.

The tables show us that the value added to the Scottish and Irish economy per fintech worker is 65 per cent higher than annual average for workers in other sectors. The multiplier effect of a fintech worker is one of the highest in any industry, largely because it is a combination of finance and IT sectors in the tables. The conclusion of such strong multiplier effects is that collaboration is net positive for both output and productivity. Table 1 shows the income and employment multiplier and the salary enhancement that collaboration could bring as a *base case*. The upside, in the event of any technological breakthrough or unicorn success is a multiple of ten times this.

TABLE 1 Multiplier effect of fintech subsector

Income multiplier	Employment multiplier	Salary assumption GBP (2018)	Salary sector enhancement
1.57	1.97	40.29	14.12

Table 2 below represents our *base case* for the net employment gain from collaborative efforts based on the identified business benefits. As can be seen, the benefits grow over time. The transformative nature of fintech can't be accurately modeled but is projected to have a strong growth trajectory.

TABLE 2 Cumulative Employment created by type by collaboration – Scotland-Ireland

	2018	2019	2020	2021	2022
Value Added	1	15	22	30	40
Intermediation	2	12	24	26	28
User Cost	5	5	5	5	5
Transformative	10	20	30	40	50
Total	18	52	81	101	123

6 | GROSS VALUE ADDED

We looked at the benefit of fintech collaboration through the lens of Gross Value Added (GVA). In national accounts GVA is output minus intermediate consumption, the balancing item in the national accounts. In 2015 financial and insurance activities account for 6.7 per cent of GVA in Ireland and 7.1 per cent of GVA in Scotland. This represents 4.5 per cent of total employment in Scotland and 3.4 per cent of total employment in Ireland. Although the employment percentages figures are lower than the GVA, the percentages are substantially higher than the 2.6 per cent job contribution of the EU as a whole. In Ireland, the banking sector is the largest financial sector (financial assets at 169 percent of GDP in 2015), followed by other financial institutions (117 percent of GDP in 2015).

Measuring bank output and productivity was addressed by (Casu, Girardone, and Molyneux, 2004). Using their method, it was first necessary to identify the productivity enhancing nature of fintech. For this reason we distinguish between three financial services (1) financial intermediation, (2) payment services and (3) other services. This approach recognizes the structure of banks and reduces the potential for biased estimations due to the use of inconsistent aggregate output measures. Total Factor Productivity (TFP) is used as a wider measure of productivity. The differentiator, intermediation, was investigated by (Philippon, 2015). He pointed out that in equilibrium, the cost of finance is the sum of the rate of returns to saver and the unit cost of financial intermediation. This is stated thus:

$$UCF = r + Uf. \quad (4)$$

Where:

- UCF = The user cost of finance,
- r = rate of return to saver,
- Uf = unit cost of intermediation.

This user cost of finance measure is important to GVA because financial companies create, trade and settle financial transactions. These are all core to the economic impact of fintech. Fintech business models are focused on the intermediation that they provide.

Payment services are core to the banking systems and hence fintech. As such, the migration of such services to the

Internet requires joint collaboration not just between Scotland and Ireland but between the entire payments ecosystem. The other services in our analysis, in a fintech context, are essentially the applications that are built to use the technology and the protocols in financial services companies designed to better serve customers.

In order to quantify the economic benefits of cooperation, we establish a basis for measurement (See Table 1). In this respect, (Berger and Humphrey) highlighted the issues in measuring the value of financial and technological production by separating quantity and price. In this way, they divide the benefits between (1) *production*, (2) *value-added*, (3) *intermediation*, (4) *user-cost* and, (5) *transactions-cost*.

The intermediation approach which is the most relevant from a fintech perspective was first commented on by (Sealy and Lindley, 1977). It focuses on the collection of deposits which are converted into loans. The fintech model in Scotland and Ireland, which bypasses this stage through peer-to-peer connection, is essentially dis-intermediary in nature. That said, incumbents are keen to ensure they are ahead of the fintech adoption curve. As such, collaboration is not only something that can contribute to productivity but also important from the perspective of preservation of market share.

7 | IMPACT AND IMPLICATIONS

As to technology itself, with the strong multiplier effect on both employment and output, we recommend the focus of co-operation be in distributed ledger. This supports the argument by (Nienaber, 2016) that incumbents need to rethink collaboration not competition. A distributed ledger is simply a ledger, or a string of records in a database, distributed and stored over the Internet in a decentralized way. Ledgers are of course central to the financial sector. Decentralization of record storing contributes to the immutability of all the copies of complete databases. Every copy would need to be altered in order to alter past records. Ledger refers to different ways the data is stored. Blockchain technology is one of the types of distributed ledger technology.

In order to understand distributed ledgers, one must also understand the concept of the blockchain. This is a secure way to transfer financial assets over the Internet using decentralized ledgers. Blockchain was a concept that gained significant attention with the rise of decentralised digital cryptographic currencies (Nakamoto, 2008).

In a report, (Oliver Wyman, 2017) argued incumbents' business models need to be reviewed. They believed this has to be done in the various layers of financial transfers, communication, identification, checking and settlements. In addition to blockchain (Bunea, Kogan, and Stolin, 2016) there are a number of other fintech areas identified that we have not yet mentioned. These including P2P-crediting, E-wallets, Bitcoins, mPOS-acquiring, T-commerce, and mobile banks. The collaboration by Scottish and Irish financial institutions of these technologies has been slow. Whilst new technologies could prove to bring more efficiency and cut down operational costs to incumbent banks, they might not increase profits.

It is not all about the incumbents. New companies also benefit from collaboration. When looking at the revenue generated by retail banks on the basis of ROE, new fintech companies have the opportunity to capture banks fees by generating activities that are not balance orientated. These gave banks 6 per cent ROE on average, where fintech payments, advice, loan origination can achieve 22 per cent ROE. In this manner, according to (Oliver Wyman, 2017), there is a great opportunity for non-capital intensive fintech businesses to provide those services.

Finally, we illustrate with table three that it is important to highlight that collaboration is not the same as fintech business models or marketing strategies. It is not based on differentiation or cost leadership, although these two elements are clearly present. In the same vein, although internal controls and incentive structures are often different between incumbents and challenger, they are not ingrained into a form of FinTech business model.

TABLE 3 This is a table that illustrates the magnitude of the impact from collaboration.

Impact	Low	Medium	High
Technology			
Distributed ledgers	-	-	Yes
Blockchain	-	Yes	-
Wireless delivery	Yes	-	-
Sector			
Banking	-	-	Yes
Fund management	Yes	-	-
Administration	-	-	Yes
Insurance	-	Yes	-

Source: CeFRI.

8 | CONCLUSION

This paper has reviewed the impact of co-operation in fintech between Scotland and Ireland. It maps the current employment of fintech companies in the two jurisdictions. It considered the holistic approach to payments and settlements, digitalization and dis-intermediation. It demonstrated that both countries face challenges in innovating their business models.

We illustrated the historical context behind Scottish and Irish collaboration. The two financial service marketplaces have enjoyed similar developments in respect of financial deregulation and the roll out of new technology. That means they are equally receptive to the new concepts. This is set to continue with recent advances in fintech which have seen advances in distributed programming and security breakthroughs in the transfer and storage of assets using the Internet.

The key contribution of this paper is in the employment effect. The multiplier effect from new employment in fintech is one of the largest in economic Input/Output analysis of both Scotland and Ireland. As a result, we conclude that new fintech approaches and innovation will increase shareholder value if the strengths of both Scotland and Ireland are combined, particularly on the future research agenda. There is the *baseline* prospect of a cumulative total of 123 new jobs that could be formed by collaboration by 2022, when taking into account value added, intermediated, user cost and trans-formative contributions. The upside from a major breakthrough in a new area like fintech is many times this.

Our findings show that collaboration, assuming no exogenous shocks, could be net positive for employment. We see employment gains in data analytics, automated compliance, and new financial applications as a direct result of such collaboration.

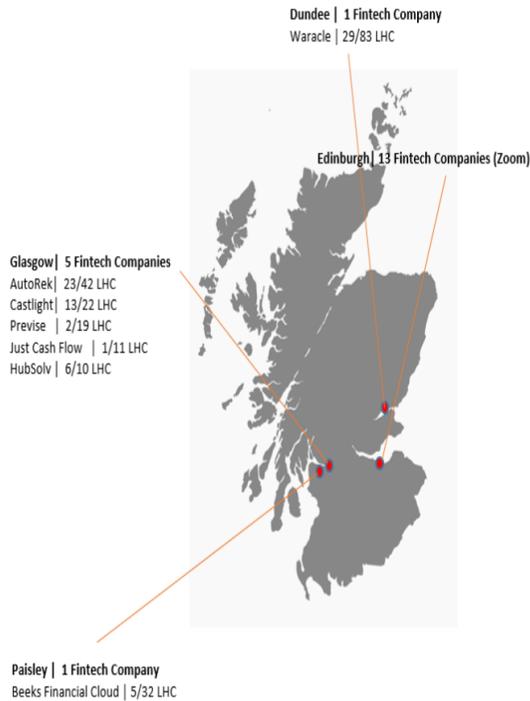
REFERENCES

- Ahuja, G. (2000). Collaboration networks, structural holes, and innovation: A longitudinal study. *Administrative science quarterly*, 45(3), pp.425-455.
- Amit, R., and Zott, C. (2001). Value creation in e-business. *Strategic management journal*, 22(6-7), pp.493-520.
- Battel, R. (2003). Ireland's "Celtic tiger" economy. *Science Technology and Human Values*, 28(1), 93-111.
- Bénétrix, A. (2015). International risk sharing and the Irish economy. *Economic and Social Review*, 46(1), 29-49.
- Berger, A., and Humphrey, D. (1992). Measurement and efficiency issues in commercial banking. In *Output measurement in the service sectors*. (pp. 245-300). : University of Chicago Press.
- Berger, A., and Humphrey, d. (n.d.). Output measurement in the service sectors. In "Measurement and efficiency issues in commercial banking", in Griliches (ed.) (p. 1992). Chicago. : University of Chicago Press.
- BIS. (2017). "FinTech credit. Market structure, business models and financial stability". Working Paper, Bank of International Settlements.
- Bunea, S., Kogan., B., and Stolin (2016). Banks versus fintechs: At last its official. *Journal of Financial Transformation*, 1-25.
- Campenon, B. (2016). Fintech and the future of securities services. *Journal of Securities Operations and Custody*, 8(2), 107-112.
- Carney, M. (2017, January 25). Speech: The Promise of FinTech – Something New Under the Sun? Wiesbaden, Germany. Retrieved from <http://www.bis.org/review/r170126b.pdf>
- Casu, B., Girardone, C., and Molyneux, P. (2004). "Productivity change in banking: A comparison of parametric and non-parametric approaches". *Journal of Banking and Finance*, , 28, 10, 2521-2540.
- Chesbrough, H. (2007). Business model innovation: it's not just about technology anymore. *Strategy and Leadership*, pp.12-17.
- Clarke, D., and Broby, D. (2017). How to foster co-operation between the Scottish and Irish Asset Management industries. In *Scottish and Irish Finance Initiative Conference*. (p. October. Scottish and Irish finance initiative.
- Diamond, D., and Dybvig, P. (1983). Bank runs, deposit insurance, and liquidity. *Journal of Political Economy*, 91:401-419.
- Ginevičius, R. (2010). The effectiveness of cooperation of industrial enterprises. *Journal of Business Economics and Management*, 11(2): 283-296.
- Jackson, A. (2012). The Two Unions: Ireland, Scotland, and the Survival of the United Kingdom, 1707-2007.
- Katz, J., and Martin, B. (1997). What is research collaboration? . *Research Policy*, , 26(1), 1-18.
- Keiding, H. (2016). *Economics and Banking*. MacMillan, Palgrave.
- Kidd, C. (1994). Gaelic antiquity and national identity in enlightenment Ireland and Scotland. *The English Historical Review*, 109(434), pp.1197-1214.
- Kim, M. (1986). Banking technology and the existence of a consistent output aggregate. *Journal of Monetary Economics*, 18, 181-195.
- Lane, P. (2012). Financial Globalisation and the Irish Economy. *Quarterly Economic Commentary*, 1-46, June.
- Leontief, W. (1936). "Quantitative input and output relations in the economic system of the United States.". *Rev Econ Stat* ., 18(3):105-125, 1936.
- Miller, R., and Blair, P. (2009). *Input-output analysis: foundations and extensions*. . Cambridge University Press.
- Mills, D. (2006). Alternative central bank policies for liquidity provisions in a model of payments. *Journal of Monetary Economics*, 53:1593-1611.
- Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system.

- Nienaber, R. (2016). Banks need to think collaboration rather than competition. . *The FinTech Book: The Financial Technology Handbook for Investors, Entrepreneurs and Visionaries*, , pp.20-21.
- O'Farrell, P. H. (1995). Business service firms in two peripheral economies: Scotland and Ireland. . *Tijdschrift voor economische en sociale geografie*, , 86(2), pp.115-128.
- Oliver Wyman. (2017, January). Retrieved from *The State of the Financial Services Industry 2017: Transforming for Future Value*.
- Philippon, T. (2015). Has the US finance industry become less efficient? On the theory and measurement of financial intermediation, . *American Economic Review* , 105, 1408-1438.
- Pittock, M. (2008). *Scottish and Irish Romanticism*. Oxford University Press.
- Ryabova, A. (2015). Emerging Fintech Market: Types and features of New Financial Technologies. *Journal of Economics and Social Sciences*, 7, 1-4.
- Samuelson, P. (1958). An exact consumption loan model of interest with or without the social contrivance of money. *Journal of Political Economy*, 66:467-482.
- Scott, W. (1951). *The constitution and finance of English, Scottish and Irish joint-stock companies to 1720*. (Vol. 1). CUP Archive.
- Sealy, C., and Lindley, J. (1977). Inputs, outputs, and a theory of production and cost at depository financial institutions. *Journal of Finance* , 32, 1251–1266.
- Thomson, A., and Perry, J. (2006). Collaboration processes: Inside the black box. . *Public Administration Review*.
- Timmers, P. (1998). Business models for electronic markets. *Electronic markets*, 8(2), pp.3-8.
- Tinianow, A. (2017). *Delaware Blockchain Initiative: Transforming the Foundational Infrastructure of Corporate Finance*. Harvard Law School Forum on Corporate Governance and Financial Regulation.
- Zott, C., Amit, R., and Massa, L. (2011). The business model: recent developments and future research. *Journal of management* , 37(4), pp.1019-1042.

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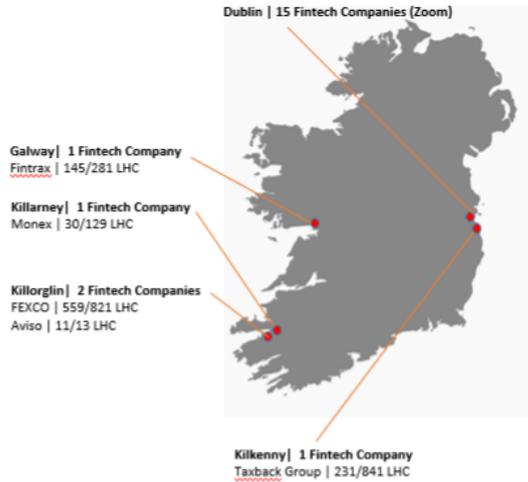
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FINTECH START-UPS IN SCOTLAND

The 20 biggest fintech companies with an office in Scotland are mapped above. The supporting data provides more details on the companies' locations in Edinburgh. There is a cluster in this area. We provide the company name and LinkedIn headcounts. The first number shows the LinkedIn headcount in Scotland and the second number is the headcount worldwide. The companies were obtained from the following sources: Fintech Scotland (<https://www.fintechscotland.com/>), Fintech Scottish Development International (<https://www.sdi.co.uk/invest/sectors/financial-services/fintech>), Scottish Financial Enterprise (<http://www.sfe.org.uk/about/groups-initiatives/fintech-strategic-initiative/>), The Scotsman (<https://www.scotsman.com/business/companies/financial/fintech>) and Fintech Scotland 2017).

Further details on the Scottish fintech ecosystem can be obtained from Fintech Scotland.
<https://www.fintechscotland.com>.



FINTECH START-UPS IN IRELAND

The 20 biggest fintech companies with an office in Ireland are mapped above. The supporting data provides more details on the companies' location in Dublin as there is a cluster in this area. We provide the company name and LinkedIn headcounts. The first number shows the LinkedIn headcount in Ireland and the second number is the headcount worldwide. The companies were obtained from the following sources: Fintech50Ireland (<https://thefintech50.com/the-fintech20-ireland/>), Fintech Ireland (<https://fintechireland.com/fintech-ireland-map.html>), LinkedIn and Irish Tech News (<https://irishtechnews.ie/irish-tech-news-fintech-20-ireland-top-20-companies-announced/>).

Further details on the Scottish fintech ecosystem can be obtained from Fintech Ireland.
<https://fintechireland.com>.



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