Abstract

Purpose – This paper presents an overview of embedded finance. It identifies the applications, use case examples, benefits and challenges of embedded finance. The paper also analyzes global interest in embedded finance and compares it with interest in related finance concepts such as open finance, open banking, decentralized finance, financial innovation, Fintech and digital finance.

Design/methodology/approach – Granger causality test and two-stage least square regression were used to assess interest over time in embedded finance.

Findings – The empirical result show that interest in embedded finance increased significantly during the COVID-19 pandemic. The United States, the United Kingdom and India witnessed the highest interest in embedded finance compared to other countries. There is bi-directional Granger causality between interest in information about embedded finance and interest in information about financial innovation. There is unidirectional Granger causality between interest in information about embedded finance and interest in information about digital finance and open finance. The findings also reveal that interest in decentralized finance and open finance are significant determinants of interest in embedded finance. On the other hand, interest in embedded finance is a significant determinant of interest in digital finance, decentralized finance, Fintech and open banking. Also, interest in embedded finance is significantly correlated with interest in digital finance, decentralized finance, open banking and Fintech.

Originality/value – Presently, there is little academic interest in embedded finance despite the fact that embedded finance is part of the ongoing digital finance revolution. This paper fills this gap in the literature by assessing the benefits, use case, challenges of embedded finance.

Keywords Embedded finance, Open finance, Open banking, Decentralized finance, Financial innovation, Fintech, Digital finance, BaaS, API

1. Introduction

Embedded finance (EF) is defined as the incorporation of a financial service or product into the platform of a non-finance company, organization or institution (Hensen and Kötting, 2022). Or, in simple term, EF is when non-financial companies or organizations include financial services as part of their services. EF permits the integration of loans, insurance, debit cards, savings and investment instruments in the platform or process of a non-finance company, organization or institution. EF is all about integrating financial services into the products, services or processes of non-financial companies. EF is essentially a merger between embedded financial services and non-financial companies. It involves the provision of financial services by a non-finance company through partnership with a technology provider, rather than a bank or other traditional financial institution.

The idea of embedding financial services into a non-financial service, product or process is not new. The idea has existed for many years but it was not given much attention until now.
The EF idea started with payments where a customer can pay for a product or service through a single application without needing to navigate to another application to enjoy the product or service. Recently, EF is gaining momentum and is becoming popular among BigTech and non-financial companies as they look to launch their own customized embedded financial services in order to create a satisfying experience for their customers. The rise in interest in EF in recent times is due to competition from new players, new customer expectations, the decomposition of the banking stack through application programming interfaces (APIs) and Banking as a Service (BaaS) providers and the need to access untapped markets. EF has the potential to disrupt traditional banking because non-finance companies will be able to embed or incorporate financial services into their platforms, and provide financial services to their customers by connecting Fintech (FT) and banks to their platforms through APIs [1] (Hensen and Kötting, 2022). This is a major shift from the FT model and traditional banking model. The ability to incorporate banking products into the platform of a non-financial company will have huge implications for traditional banking and FT business. While EF is popular among practitioners, academics have shown very little interest in EF as a subject of research inquiry. Presently, there is no rigorous research or study about EF in the academic literature. The scant research in this area creates an opportunity for academic and policy researchers to explore 1) how EF can co-exist or transform traditional finance, 2) how EF can improve the welfare of users, 3) how EF might disrupt traditional banking, 4) whether EF will increase or decrease systemic risk in the financial system, 5) how EF can support financial stability goals, 6) the regulatory changes that need to be made to allow embedded financial services to thrive particularly the licensing requirements, regulatory and supervisory rules and 7) suggestions on how regulators can catch up with developments in EF. Extensive academic and policy research is needed in these areas in order to develop the academic and policy literature on EF.

The purpose of this paper is to present an overview of EF. The paper highlights the applications and use case examples of EF. The paper also identifies the role of financial institutions in the EF sector. The paper further highlights the benefits and challenges of EF. The paper concludes with an analysis of global interest in EF and compares it with interest in related finance concepts such as open finance (OPF), open banking (OPB), decentralized finance (DCF), financial innovation (FIN), FT and digital finance (DF). The discussion in this paper can provide valuable insights that can help economists, researchers, policy makers and academics gain a comprehensive understanding of EF and what the EF agenda is about.

The discussion in this paper contributes to the literature in the following way. First, it contributes to the financial innovation literature. Notable studies in this literature include Frame and White (2004), Tufano (2003) and Allen (2012). This paper contributes to the financial innovation literature by promoting EF as a potential breakthrough in financial services because it permits the decentralization of financial services as non-finance companies will be able to provide financial services, and it will also make financial services accessible to customers at purchase end-points when buying goods or services, thereby providing convenience to users. Second, the study contributes to the digital finance literature. Notable studies in this literature include Ozili (2018), Ketterer (2017) and Gomber et al. (2017). This paper contributes to the financial innovation literature by showing that digital protocols (i.e. APIs) can be used to connect banks and Fintech companies with the platform of non-finance companies to allow non-finance companies provide seamless financial services to customers or users.

The rest of the paper is structured as follows. Section 2 presents the review of related literature. Section 3 presents some applications and use case examples of embedded financial services. It also presents some global statistics on EF. This section also highlights the role of financial institutions in EF. Section 4 identifies some benefits and challenges of EF. Section 5 presents the empirical analysis of interest over time data relating to EF and related concepts. Section 6 concludes the paper.
2. Literature review

There are very few existing academic studies about EF in the literature. The few academic studies in the literature suggest that academics have not paid attention to the emerging EF opportunity. Much of the existing discussions about EF are practitioner white papers. For instance, Hensen and Kötting (2022) argue that open banking laid the foundation that enable banks to embed financial services into the products of non-bank companies to provide convenience to their clients. They show that Deutsche Bank launched an API program in 2015, and the program was successful because it enabled Deutsche bank to integrate its banking data, financial products and services into the applications and products of non-finance companies who are its EF partners. Teboul and Anastasiou (2020) suggest some criteria that should be taken into account by EF partners. They suggest that EF partners need to work with an EF provider that has a global footprint, such as a global banking license, a global network, multiple payment capabilities, a large balance sheet and a diverse business, so that the EF providers can support EF partners as they grow.

Smith and Wallraff (2021) assess the EF opportunity, and argue that EF has the ability to transform finance in remarkable ways. They argue that financial institutions need to position themselves to take advantage of EF opportunity. They suggest that financial institutions should develop their own EF strategy. Torrance (2021) argues that EF enables the integration of low-cost innovative financial services into new propositions and customer experiences. Torrance showed that FT companies are taking the lead in creating sophisticated EF offerings through BaaS platforms. Torrance (2021) then states that financial institutions, particular banks and insurance companies, need to take a bolder and strategic step to take advantage of the EF opportunities around them. Torrance further identified three key issues that financial institutions need to address to take advantage of the EF opportunity. They include 1) leadership understanding and commitment; 2) choosing the right organizational structure, operating model and skills needed to enter the EF market and 3) developing technical capability.

Anthemis (2019) makes an important point about the existence of EF and the need to scale embedded financial services through investment. Anthemis (2019) point out that many non-finance companies already have an EF layer in their business but customers and investors have never noticed it or considered it. Anthemis (2019) called for more investment in EF, and suggests that investment should be made into the EF sector by directing capital to the financial services companies that have components that embed into non-finance companies; and secondly, by investing in non-finance companies that have value propositions that are significantly enhanced through the associated financial products and services embedded within. Ohnishi (2021) argues that EF has been made possible by the unbundling of financial service functions brought about by technological progress and deregulation, and that EF will become an irreversible trend. Ohnishi (2021) argues that EF can increase the revenue of non-finance companies, it can lead to high customer retention by offering convenience, and it can strengthen their core business.

Olins (2021) show that EF has benefits for small businesses. Olins (2021) argues that small businesses are affected by lack of access to affordable and timely financial services. Olins (2021) then argues that embedded financial services will enable small businesses to: raise capital, meet operational financial needs and have access to tailored financial services to help small businesses succeed. Principato (2022) suggests ways in which EF will disrupt traditional financial services. Principato (2022) argues that consumers encounter embedded payments regularly, and consumers are becoming accustomed to using nonfinancial apps to make payments on platforms such as Apple Pay, Google Pay or Shop Pay. Principato (2022) then argues that as consumers experience the ease of payments embedded in their brand experiences, they will wonder why their banks make transactions so hard. This might lead to loss of bank customers when a large number of customers prefer to use embedded payment services. Hoffman (2022) focused on how EF affects trade finance. Hoffman (2022) argues that the parties involved in trade want convenience but there has been a long standing disconnect between physical supply chain
and financial supply chain. Hoffman (2022) show that EF has the potential to align the disconnected physical and financial supply chains, and this alignment will be a major factor in opening more financing opportunities for small and medium-sized enterprises (SMEs) involved in trade, and may help in narrowing the global trade finance gap.

Prasad (2022) points out that EF can change how financial services are consumed, but its transparency and how EF services are deployed for consumers will be critical in determining whether regulators will approve and support the deployment of embedded financial services in the banking sector. Mulye (2021) argues that EF will enable MSME, B2C and B2B businesses to increase their customer lifetime value, monetize their customer base and vertically scale their product offering. Mulye (2021) also points out that digital platforms will play an important role in the distribution of embedded financial services. As a result, there is need for lenders to partner with digital platforms in order to acquire a diverse pool of customers available to them in the market.

3. Embedded finance: application, use case, global statistics and the role of financial institutions

This section highlights the application of EF and the use case examples of EF. It also presents some global statistics about the EF opportunity, and the role of financial institutions in the EF sector.

3.1 Applications of embedded finance

One of the biggest applications of EF is embedded lending. Embedded lending occurs when non-finance companies offer loans to customers and employees through APIs and in partnership with a bank or other lenders. Embedded lending involves incorporating one or more loan products into the platform of a non-finance company through APIs. Non-finance companies will partner with banks, and connect their platform to a bank’s loan offering through APIs. Embedded lending also allows non-finance companies to access loans easily to meet payroll needs. It gives employees easy access to loans to meet personal needs. It can also help non-finance companies to meet customer needs especially customers who want to complete a purchase but do not have enough money to pay for it instantly. Embedded lending can help small businesses obtain the capital they need to grow their business. Another application of EF is embedded insurance. Embedded insurance occurs when non-finance companies offer to sell insurance together with the purchased product at the same time so that customers do not have to go to a separate insurance provider to insure the purchased product. Embedded insurance can reduce the cost of purchasing insurance, reduce the cost of insurance distribution, and provide convenience to customers. Another application of EF is embedded payments. Embedded payments occur when non-finance companies offer direct bank-to-bank transfers which saves transaction cost for non-finance companies and their clients. Another application of EF is embedded investment and trading. Embedded investment and trading occurs when non-finance companies provide access to stocks and debt instruments on their platforms. It also allows non-finance companies to integrate stock market investing capabilities into their product offerings through the API of major stock exchanges that are embedded on the platform of non-finance companies. Another application of EF is in trade finance or embedded trade. Inadequate trade finance is one of the top three export barriers in the world, according to the World Economic Forum [2]. Embedded trade finance, or embedding financial services into the trade ecosystem helps to (1) link more parties within the trade value chain, (2) exchange funds at various points in the logistical trade process and (3) ease some of the upfront burdens that financiers face in the trade finance process.
3.2 Use case examples of embedded finance

Below are some use case examples of EF.

**Uber** – Uber offers embedded financial services in its taxi hailing app. Users of Uber app are able to book a ride and make instant payment on the same app without navigating to another app to make payment. Also, the drivers can receive payment, notification of payment receipts, and obtain loans and discounts on the Uber app. Drivers can also open a bank account on the Uber app. The Uber use case example is probably one of the most advanced use case of embedded financial services in the world today.

**Swatch** – Swatch is a watchmaker. The wrist watch produced by Swatch has the ability to issue tokenized payment cards through SwatchPay.

**Amazon** – The e-commerce giant offers financial products on its platform by selling Amazon reward cards and Amazon credit cards.

**Apple** – Apple offers its own credit cards. Apple also allows users to use their mobile phones as payment devices online and offline.

**TikTok** – TikTok is a video social platform similar to YouTube. The social platform partnered with Shopify to integrate shopping capabilities into the Tiktok app.

**Grab** – Grab is a delivery service app in Singapore that offers merchant point of sale, insurance and other financial products.

**Lyft** – Lyft is a taxi hailing app similar to Uber. Lyft allows users to request a ride and pay for it with a credit card or debit card on the app. Lyft offers financial products such as Lyft Cash, Lyft Direct Debit Mastercard and bank account service by partnering with Payfare and Stride Bank.

**Tesla** – Tesla offers embedded insurance services. Tesla offers insurance to all drivers purchasing a Tesla car. It eliminates the need for drivers to explore other providers of insurance since Tesla already has details about the vehicle and owner or driver.

**Zillow** – Zillow is a real estate giant in the United States. Zillow embedded loans into its service offering to customers by launching the Zillow Home Loans in 2019. Zillow also expanded into agent and lender services through Zillow Closing Services.

**Google Maps** – Google Maps have a built in payment service that allows users to purchase street parking ticket before they reach their destinations to avoid getting towed or ticketed. The payment service on the app is fast and quick.

**BNPL services** – The Buy-Now-Pay-Later (BNPL) scheme is the most common e-commerce payment method in Sweden and in other countries. The BNPL service is made possible through EF. With EF, people will be able to make a purchase now and choose to pay later. Many apps exist that offer BNPL services, and the number of BNPL users is likely to increase to 1.5 billion by 2026 according to Juniper Research [3]. Also, BNPL transactions are likely to constitute 4.2% of all global e-commerce transactions by 2024 according to a WorldPay forecast [4].

3.3 Global statistics about the embedded finance opportunity

Forecasts and research reports conducted by financial companies and research institutes show that:

(1) EF is worth $3.5 trillion in the global retail sector, according to research from cloud banking platform Mambu [5];

(2) The worldwide value of venture capital investments in EF exceeded $4 billion in September 2021, according to data from statistia.com. [6]

(3) The retail sector will account for 49% of the EF market within the next 10 years, according to a forecast by Mambu [7];

(4) The global opportunity for EF is estimated to reach $7 trillion in the next 10 years, according to a study “the Next-Gen Commercial Banking Tracker”. A joint study by PYMNTS and FISPAN collaboration [8].
3.4 Role of financial institutions in embedded finance

Each financial institution needs to decide on the exact role it will play in the EF model. Generally, financial institutions have a role to play in API integration. An API is a code used to share information between two systems. An API is simply an interface that allows one party to have access to the information or services of another party in exchange for a fee and in compliance with specified data sharing arrangements and agreements. APIs are central to integrating financial services into digital systems. The API used to integrate financial services into digital systems has to be monitored regularly to identify necessary changes and areas for improvements. Improvement in an API can be done through an update of the same API or a complete upgrade to a higher version of the API.

Financial institutions need to ensure that the API technology is robust and effectively integrated into the platform of the EF partner. This can be achieved through extensive testing. The testing should ensure that all data formats, API standards, technical problems and other customer experience issues are resolved before the embedded solution is allowed to go live. Much attention should be placed on the sharing of personal data between financial institutions and the EF partners. Data controller, joint controller or processor roles should also be assigned appropriately. Financial institutions and the EF partners should also ensure that data transfer arrangements through APIs satisfy legal and regulatory requirements. Financial institutions, such as Fintech and banks, need to cooperate rather than compete in order to enjoy the benefits of EF. Financial institutions also need to provide customer data in accordance with existing regulations and laws. Financial institutions should offer BaaS that non-finance companies can use to serve their customers. And since BaaS is often distributed to EF partners through APIs, financial institutions should adopt strong risk management and compliance systems to prevent data breach when sharing data with EF partners. Financial institutions will also need new business models to enable them compete and retain market share in the EF model.

4. Benefits and challenges of embedded finance

This section highlights some benefits of EF and the challenges of EF.

4.1 Benefits of embedded financial services

One, EF can increase revenue for parties involved in an EF arrangement. EF will enable businesses in every sector to generate new revenue streams or augment their existing revenue streams. This will be achieved by incorporating a financial services segment into their business platform to enhance customer experience. It will lead to greater customer patronage and increase in revenue. EF can also help non-finance companies establish new revenue streams. Two, EF can make every non-finance company a financial service provider. EF has made it possible for every company to become a financial service provider if they so wish. With the emergence of embedded financial services enabled through APIs, any non-finance company can obtain a license and the necessary regulatory approvals needed to become a provider of financial services. This means that banks will no longer possess the
monopoly of providing financial services. Everybody, both financial and nonfinancial companies, will be able to offer financial services. Three, EF leads to a better payment experience. EF has the potential to improve the payment experience of customers. Customers can enjoy a seamless payment experience by using the payment API offered on the app or website of non-finance companies rather than re-directing customers to external portals or asking customers to use the cumbersome bank app to make payments. Embedded payment improves the payment experience of users by ensuring that the entire purchase and checkout process happens in one place. Four, EF can assist in automating the bookkeeping process of businesses. Embedded financial accounting APIs can help non-finance companies to automate the book-keeping process. By embedding financial accounting APIs into the payment process of non-finance companies, these companies will be able to seamlessly automate their financial records, monitor payment inflows and outflows and detect fraudulent activities immediately. Five, EF offers other benefits. Embedded financial services can generate useful consumer data which can be used to understand consumer buying behavior and pattern. Embedded financial services can also increase the competitiveness of the products and services offered by companies using embedded financial services. EF presents an opportunity to give companies a competitive advantage in the market place. EF can lead to high customer retention by offering convenience. It can also help to strengthen the core business of financial institutions and non-finance companies.

4.2 Challenges of embedded finance

One notable challenge of EF is that embedding financial services can create ambiguity about who should take responsibility for regulatory violations. For instance, when customers’ data privacy has been violated, it can be difficult to tell which party is responsible for the data breach and which party should be sanctioned. Should only the financial institution or the API developer or the API provider or the non-finance company be sanctioned? Or, should all parties involved in an EF arrangement be sanctioned together? Regulators will have to conduct series of interviews and investigations, including paperwork, to determine who is responsible for consumer data privacy violation, and they would spend much time and resources to conduct such investigation and such effort may be an unnecessary waste of regulator’s time and resources. Another challenge is the complex commercial relationship that will arise from adopting embedded financial services. Take the case of embedded lending, for example. When a non-finance company gives bank loans through its platform, a problem that arises is that the bank does not know the borrower of the embedded loans. This can make loan recovery difficult for the bank. The bank, whose loan was embedded into the platform of a non-finance company, does not have a direct relationship with the end customer. Another dimension of the complex commercial relationship problem is that consumers will be engaging with products or services from two separate organizations. This can create a problem for the customer because customers may not know which one of the two organizations is responsible for the different parts of the product purchase experience, and customers may not know which organization to complain to when they have complaints about specific parts of the financial product or service. There will also be regulatory challenges relating to data security. Another challenge is that traditional banks may refuse to promote a third party’s API to the financial ecosystem. Another challenge is that EF can make banks lose market share. Also, lack of partnership can limit progress in EF. Financial institutions may have reasons for refusing to partner with API providers and non-finance companies. Notwithstanding, embedded finance needs partnership: partnership with API providers, partnership with financial institutions, partnership with the end user, and partnership with regulators. Finally, using embedded financial services to the fullest may require lowering anti-money laundering and know-your-customer (KYC) regulations which can expose businesses to payment fraud.
5. Assessing interest in embedded finance

5.1 Data

Discussions about EF often lead to discussions about OPF, OPB, FIN, DF, FT and DCF. This indicates that these finance concepts may be interrelated. Accordingly, in this section, I assess the global interest in EF and compare it with the global interest in OPF, OPB, FIN, FT, DF and DCF. Interest over time monthly data were obtained from Google trend database on a global basis. The global interest over time data were collected for the following web search terms: “embedded finance” (EF), “open finance” (OPF), “open banking” (OPB), “financial innovation” (FIN), “digital finance” (DF), Fintech (FT) and “decentralized finance” (DCF) from January 2004 to December 2021. The global interest over time data measures the popularity of a search term on Google using the web search category. Table 1 reports the descriptive statistics. The aggregate mean for the variables show that there was greater interest in information about OPF, OPB and DF over the period and a relatively low interest in information about EF, FT and DCF during the same period.

The annual trend in the individual variables was assessed separately in Figure 1. Figure 1 shows that interest in OPF reached its high peak in 2010 just after the global financial crisis, and began to decline afterward. Meanwhile, interest in DF and OPB rose significantly from 2013 onward while interest in EF and DCF remained low from 2004 to 2018 and began to rise in the post-2019 years. This indicates that interest in information about EF began to gain traction from 2019 onward during the COVID-19 pandemic. Interest in FT rose significantly from 2014 up until 2021. Also, interest in DF, EF, OPF, OPB, FT and DCF increased significantly during the COVID-19 pandemic. Figure 2 shows that Singapore, India and the United Kingdom had the highest level of interest in Internet information about EF during the 2004 to 2021 period.

| Month/Variable | EF (mean) | DF (mean) | DCF (mean) | FIN (mean) | OPB (mean) | OPF (mean) | FT (mean) |
|----------------|-----------|-----------|------------|------------|------------|------------|-----------|
| 2004           | 6.41      | 32.66     | 11.41      | 49.25      | 11.08      | 23.25      | 2.08      |
| 2005           | 4.25      | 27.41     | 11.75      | 42.08      | 10.33      | 33.75      | 1.66      |
| 2006           | 8.66      | 25.91     | 10.83      | 36.66      | 13.66      | 54.83      | 1.58      |
| 2007           | 17.08     | 30.66     | 10.41      | 33.41      | 13.91      | 60.75      | 1.75      |
| 2008           | 16.33     | 32.41     | 10.33      | 31.33      | 16.33      | 61.08      | 1.58      |
| 2009           | 16.41     | 34.75     | 9.08       | 35.5       | 23.41      | 77.25      | 1.25      |
| 2010           | 5.75      | 33.25     | 8.66       | 27.91      | 28.91      | 84.5       | 1.41      |
| 2011           | 6.92      | 29.66     | 9.91       | 26.66      | 26         | 73.66      | 1.33      |
| 2012           | 9         | 26.91     | 9.33       | 25.33      | 23.91      | 53.83      | 1.41      |
| 2013           | 7.41      | 26.5      | 8.75       | 23.33      | 25.25      | 49.33      | 2.16      |
| 2014           | 7.91      | 29.58     | 8.08       | 22.66      | 29.25      | 45.16      | 3.5       |
| 2015           | 8.25      | 32.25     | 8.25       | 24.91      | 31.08      | 41.83      | 12.91     |
| 2016           | 9.91      | 39.08     | 7.75       | 24.58      | 32.33      | 32.33      | 33.83     |
| 2017           | 11.08     | 48.16     | 6.41       | 21.91      | 43.58      | 35         | 47.33     |
| 2018           | 10.33     | 55.75     | 6.33       | 24.58      | 59.58      | 36.33      | 59        |
| 2019           | 13.41     | 62        | 6.75       | 20         | 65.5       | 39.83      | 73        |
| 2020           | 21.17     | 71.58     | 17.58      | 20         | 72         | 48.83      | 67.33     |
| 2021           | 45.5      | 80.91     | 69.41      | 22.83      | 79.83      | 47.16      | 79.08     |

**Aggregate**

Mean: 12.54 39.97 12.83 28.5 33.69 49.93 21.97
Median: 10 35 9 26 28 47 2
Maximum: 71 91 100 100 100 100 100
Minimum: 0 5 5 0 4 12 1
Std. Dev: 12.04 17.59 14.58 13.71 21.47 17.41 28.89
Observations: 216 216 216 216 216 216 216

**Note(s):** Annual mean of the interest over time data was obtained by taking the average of the monthly interest over time value for each year.

Table 1. Interest over time: descriptive statistics
5.2 Granger causality test

I perform Granger causality tests for the interest over time variables. An augmented Dickey–Fuller test was first conducted to determine whether each of the time series has a unit root process. The result in Table 2 shows that the OPB, EF, OPF, FIN and DF time series has a unit root and is therefore non-stationary while only the DCF time series is stationary. As a result, the OPB, EF, OPF, FIN and DF time series were first-differenced before performing the Granger causality test. The Granger causality test result is reported in Table 3. There is a two-way Granger causality between \( d(\text{FIN}) \) and \( d(\text{EF}) \) as their \( p \)-values are 0.0161 and 0.0001 which are less than 0.05 in Table 3. This indicates that there is bi-directional Granger causality between interest in information about EF and interest in information about FIN. Also, there is one-way Granger causality...
causality between \(d(\text{EF})\) and \(d(\text{OPF})\) as the \(p\)-value is 0.0011 which is less than 0.05. This indicates that there is uni-directional Granger causality between interest in information about \(\text{EF}\) and interest in information about \(\text{OPF}\). Furthermore, there is one-way Granger causality between \(d(\text{EF})\) and \(d(\text{DF})\) as the \(p\)-value is 0.0004 which is less than 0.05 in Table 3. This indicates that there is uni-directional Granger causality between interest in information about \(\text{EF}\) and interest in information about \(\text{DF}\). Overall, the result suggests that interest in information about embedded finance causes interest in information about open finance, digital finance and financial innovation.

5.3 Determinant of interest in embedded finance

I perform a two-stage least square (2SLS) regression estimation to determine whether interest in DCF, OPF, FT, OPB, FIN and DCF are determinants of interest in EF. The two-stage least square (2SLS) regression estimation was used to address any endogeneity problems in the data. The 2SLS regression result is reported in column 1 of Table 4. The DCF, OPF and FT coefficients are significant and positively related to EM while the OPB, FIN and DF coefficients are statistically insignificant. The result implies that greater interest in information about DCF, OPF and FT lead to greater interest in information about EF.

| Variable | Symbol | T-Statistic | \(p\)-value | Remark |
|----------|--------|-------------|-------------|--------|
| Interest in information about embedded finance | EF | -1.929 | 0.318 | Has a unit root. EF is non-stationary. To be first-differenced i.e. \(d(\text{EF})\) |
| Interest in information about open finance | OPF | -1.929 | 0.318 | Has a unit root. OPF is non-stationary. To be first-differenced i.e. \(d(\text{OPF})\) |
| Interest in information about open banking | OPB | -0.665 | 0.852 | Has a unit root. OPB is non-stationary. To be first-differenced i.e. \(d(\text{OPB})\) |
| Interest in information about financial innovation | FIN | -2.128 | 0.234 | Has a unit root. FIN is non-stationary. To be first-differenced i.e. \(d(\text{FIN})\) |
| Interest in information about digital finance | DF | 1.458 | 0.999 | Has a unit root. DF is non-stationary. To be first-differenced i.e. \(d(\text{DF})\) |
| Interest in information about Fintech | FT | 0.855 | 0.995 | Has a unit root. FT is non-stationary. To be first-differenced i.e. \(d(\text{FT})\) |
| Interest in information about decentralized finance | DCF | -3.969*** | 0.002 | Does not have unit root. DCF is stationary |

Note(s): *** represents significance at the 1% level

Period: 2004: January – 2021: December
Lags: 2

| Null Hypothesis | Obs | \(F\)-Statistic | Prob |
|-----------------|-----|-----------------|------|
| \(d(\text{DF})\) does not Granger cause \(d(\text{EF})\) | 213 | 1.046 | 0.3529 |
| \(d(\text{EF})\) does not Granger cause \(d(\text{DF})\) | | 8.018*** | 0.0004 |
| \(\text{DCF}\) does not Granger cause \(d(\text{EF})\) | 213 | 1.194 | 0.3048 |
| \(d(\text{EF})\) does not Granger cause \(\text{DCF}\) | | 0.477 | 0.6211 |
| \(d(\text{FIN})\) does not Granger cause \(d(\text{EF})\) | 213 | 4.215** | 0.0161 |
| \(d(\text{EF})\) does not Granger cause \(d(\text{FIN})\) | | 9.218*** | 0.0001 |
| \(d(\text{OPB})\) does not Granger cause \(d(\text{EF})\) | 213 | 0.002 | 0.9971 |
| \(d(\text{EF})\) does not Granger cause \(d(\text{OPB})\) | | 0.681 | 0.5072 |
| \(d(\text{OPF})\) does not Granger cause \(d(\text{EF})\) | 213 | 1.926 | 0.1483 |
| \(d(\text{EF})\) does not Granger cause \(d(\text{OPF})\) | | 7.069*** | 0.0011 |
| \(d(\text{FT})\) does not Granger cause \(d(\text{EF})\) | 213 | 0.434 | 0.6479 |
| \(d(\text{EF})\) does not Granger cause \(d(\text{FT})\) | | 0.134 | 0.8737 |

Note(s): ***, ** represent significance at the 1% and 5% level
5.4 Sensitivity analysis: lagged effect and the determinants of interest in embedded finance

I perform an additional sensitivity test to determine whether taking the one-year lag of the explanatory variables would alter the earlier results obtained in column 1 of Table 4. This analysis allows us to assess whether interest in DCF, OPF, OPB, FIN, FT and DCF drives interest in EF. The regression result is reported in column 2 of Table 4. The DCF and OPF coefficients remain significant and positively related to EM while the OPB, FT, DF and FIN coefficients are statistically insignificant. This result further confirms that greater interest in information about DCF and OPF leads to greater interest in information about EF.

5.5 Additional analysis

In a separate analysis, I examine whether interest in EF has a direct impact on interest in DF, DCF, OPF, OPB, FT and FIN. In the analysis, interest in EF is introduced as the explanatory variable while the interest in DF, DCF, FT, OPF, OPB and FIN variables are the dependent variables. The result is reported in Table 5. The result shows that the EM coefficient is significant and positively related to DF, DCF, OPB and FT in columns 1, 2, 4 and 6 of Table 5, respectively. This implies that greater interest in information about EF leads to greater interest in information about DF, DCF, OPB and FT.

Furthermore, I examine whether the lagged EM variable has a direct impact on interest in DF, DCF, OPF, FT, OPB and FIN. The result in Table 6 remain significant which indicates that greater interest in information about EF leads to greater interest in information about DF, DCF, FT and OPB. Finally, the Pearson correlation matrix reported in Table 7 shows that interest in EF has a positive and significant correlation with DF, DCF, OPB and FT.

| Dependent variable: EF Coefficient (t-statistic) | Dependent variable: EF Coefficient (t-statistic) |
|-------------------------------------------------|-------------------------------------------------|
| C                                               | $-6.908^{**} (-2.19)$                           | $-4.084 (-1.29)$ |
| DF                                              | $0.123 (1.56)$                                 |                  |
| DCF                                             | $0.421^{***} (8.64)$                           |                  |
| FIN                                             | $0.059 (1.27)$                                 |                  |
| OPB                                             | $-0.066 (-0.81)$                               |                  |
| OPF                                             | $0.142^{***} (3.51)$                           |                  |
| FT                                              | $0.116^{*} (1.68)$                             |                  |
| DFt-1                                           | $0.143^{*} (1.81)$                             |                  |
| DCFt-1                                          | $0.463^{***} (9.08)$                           |                  |
| FINt-1                                          | $0.001 (0.01)$                                 |                  |
| OPBt-1                                          | $-0.056 (-0.68)$                               |                  |
| OPFt-1                                          | $0.107^{***} (2.62)$                           |                  |
| FTt-1                                           | $0.080 (1.15)$                                 |                  |
| R-squared                                       | 52.59                                          | 52.38            |
| Adjusted R-squared                              | 51.24                                          | 51.01            |
| $F$-statistic                                   | 38.65                                          | 38.14            |
| Prob ($F$-statistic)                            | $0.000$                                        | $0.000$          |
| $J$-statistic                                   | $0.000$                                        | $0.000$          |

Table 4. Determinants of interest in information about embedded finance (EF) (Two-stage least square regression estimation)

Note(s): The two-stage least square instruments used in the regression in column 1 are the DF, DCF, FIN, OPB, FT, OPF explanatory variables. The two-stage least square instruments used in the regression in column 2 are the lagged explanatory variables (DFt-1, DCFt-1, FINt-1, OPBt-1, OPFt-1). DFSLS in $^{***}$, $^{**}$ represent significance at the 1% and 5% level.
|                      | (1) Dependent variable: DF | (2) Dependent variable: DCF | (3) Dependent variable: FIN | (4) Dependent variable: OPB | (5) Dependent variable: OPF | (6) Dependent variable: FT |
|----------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
|                      | Coefficient (t-statistic)   | Coefficient (t-statistic)   | Coefficient (t-statistic)   | Coefficient (t-statistic)   | Coefficient (t-statistic)   | Coefficient (t-statistic)   |
| c                    | 29.795*** (20.654)          | 2.674** (2.50)              | 29.233*** (21.65)           | 22.772*** (13.22)           | 48.561*** (28.37)           | 7.786*** (3.09)             |
| EF                   | 0.811*** (9.77)             | 0.810*** (13.15)            | -0.068 (0.75)               | 0.871*** (8.18)             | 0.109 (1.11)                | 1.116*** (7.69)             |
| R-squared            | 30.84                       | 44.73                       | -0.26                       | 23.84                       | 0.56                        | 21.65                       |
| Adjusted R-squared   | 30.52                       | 44.47                       | -0.20                       | 23.48                       | 0.1                         | 21.29                       |
| F-statistic          | 95.43                       | 173.16                      | 0.566                       | 66.98                       | 1.226                       | 59.15                       |
| Prob (F-statistic)   | 0.000                       | 0.000                       | 0.000                       | 0.000                       | 0.000                       | 0.000                       |
| J-statistic          | 0.000                       | 0.000                       | 0.000                       | 0.000                       | 0.000                       | 0.000                       |

**Note(s):** The two-stage least square instrument used in the regression in column 1–5 is the EF explanatory variable. ***, ** represent significance at the 1% and 5% level.
**Table 6.** Effect of lagged interest in embedded finance (EF) on interest in DF, DCF, FIN, OPB, and OPF: Two-stage least square regression estimation

|        | (1) | (2) | (3) | (4) | (5) | (6) |
|--------|-----|-----|-----|-----|-----|-----|
|        | Dependent variable: DF | Dependent variable: DCF | Dependent variable: FIN | Dependent variable: OPB | Dependent variable: OPF | Dependent variable: FT |
|        | Coefficient (t-statistic) | Coefficient (t-statistic) | Coefficient (t-statistic) | Coefficient (t-statistic) | Coefficient (t-statistic) | Coefficient (t-statistic) |
| **c**  | 30.83*** (20.38) | 2.792** (2.56) | 28.828*** (21.21) | 23.425*** (12.44) | 49.789*** (29.07) | 8.505*** (3.31) |
| Eft-1  | 0.738*** (8.37) | 0.811*** (12.79) | −0.026 (−0.33) | 0.836*** (7.62) | 0.023 (0.23) | 1.079*** (7.21) |
| R-squared | 24.76 | 43.43 | 0.05 | 21.39 | 0.02 | 19.62 |
| Adjusted | 24.41 | 43.16 | −0.4 | 21.03 | −0.04 | 19.25 |
| R-squared | 24.41 | 43.16 | −0.4 | 21.03 | −0.04 | 19.25 |
| F-statistic | 70.11 | 163.54 | 0.107 | 57.99 | 0.055 | 52.01 |
| Prob (F-statistic) | 0.000 | 0.000 | 0.744 | 0.000 | 0.815 | 0.000 |
| J-statistic | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

**Note(s):** The two-stage least square instrument used in the regression in column 1–5 is the one-year lagged EF explanatory variable. ***, ** represent significance at the 1% and 5% level.
6. Conclusion

This paper presented an overview of EF. It highlighted the applications, use case examples, benefits and challenges of EF. Some of the benefits of embedded finance include: increase in revenue, the possibility of every company becoming a financial service provider, better payment experience, the automation of the bookkeeping process and other benefits. Some identified challenges of embedded finance include ambiguity about who should take responsibility for regulatory violations, complex commercial relationships, loss of market share for banks and other financial institutions and lack of partnership. Empirical analysis of interest in EF showed that interest in EF increased significantly during the COVID pandemic. Singapore, India and the United Kingdom witnessed the highest interest in EF compared to other countries. There is bi-directional Granger causality between interest in information about EF and interest in information about FIN. There is uni-directional Granger causality between interest in information about EF and interest in information about DF and OPF. The findings also show that interest in DCF and OPF are significant determinants of interest in EF. On the other hand, interest in EF is a significant determinant of interest in DF, DCF, FT and OPB.

The implication of the empirical findings is that the EF revolution is linked to developments in DF, DCF and OPB and finance. This means that an EF strategy needs to leverage on existing DF, DCF and OPB and finance systems. In the future, there will be greater emphasis on openness and digitalization in finance to fully tap into the $7.2trillion global EF opportunity.

Customers, practitioners, policy makers and researchers have a role to play in the EF journey. Customers can take advantage of the convenience that embedded services bring to them. Practitioners and businesses can reinvent their business models, and find ways to integrate embedded financial technology into their business models so as to create new revenue streams and generate additional income. Policy makers and regulators should

| Variables | EF   | DF  | DCF  | FIN  | OPB  | OPF  | FT  |
|-----------|------|-----|------|------|------|------|-----|
| EF        | 1.00 |     |      |      |      |      |     |
| DF        | 0.555*** (9.76) | 1.00 |      |      |      |      |     |
| DCF       | 0.668**** (13.15) | 0.558*** (9.85) | 1.00 |      |      |      |     |
| FIN       | -0.051 (0.45) | -0.256*** (-3.87) | -0.049 (-0.73) | 1.00 |      |      |     |
| OPB       | 0.488*** (8.18) | 0.861*** (24.75) | 0.493**** (8.30) | -0.392*** (-6.24) | 1.00 |      |     |
| OPF       | 0.075 (0.00) | -0.185*** (-2.76) | -0.028 (-0.42) | -0.027 (-0.40) | -0.151** (2.24) | 1.00 |     |
| FT        | 0.465*** (7.69) | 0.883*** (27.62) | 0.447*** (7.32) | -0.315*** (-4.86) | 0.918*** (34.09) | -0.351*** (5.49) | 1.00 |

Note(s): ***, ** represent significance at the 1% and 5% level. T-statistic is reported in single parenthesis. p-value is reported in double parenthesis.

Table 7. Pearson correlation matrix for the variables.
constantly review the existing EF infrastructure, particularly, API security, data sharing arrangements and the design of embedded products and services to ensure that they comply with existing consumer protection and data privacy laws and regulations. Policy makers and regulators should also create an enabling environment for EF innovations to thrive. Academics and researchers can use available data to establish relationships between EF and economic aggregates to determine whether EF developments have a positive or negative effect on the economy and society at large.

Future studies can investigate whether EF improves financial inclusion for the unbanked segments of society. Future studies can also assess the prospects of EF in developing countries, and suggest the best use case of EF that works well for developing countries. Future studies can also investigate whether the presence of good institutions support EF developments.

Notes
1. An API is a type of code used to simplify interactions between systems and services.
2. https://www.weforum.org/agenda/2020/02/exporters-mind-trade-finance-gap/
3. https://www.juniperresearch.com/whitepapers/buy-now-pay-later-the-future-of-ecommerce
4. The Global Payments Report 2021, WorldPay from FIS, https://worldpay.globalpaymentsreport.com/en/
5. https://mambu.com/aws-next-digital-revolution
6. https://www.statista.com/statistics/1271706/embedded-finance-vc-investments/
7. https://mambu.com/aws-next-digital-revolution
8. https://www.pymnts.com/tracker/next-gen-commercial-banking/b2b-payments-corporate-finance/
9. Forbes Business Council. https://www.forbes.com/sites/forbesbusinesscouncil/2022/04/27/the-future-of-embedded-payments-what-the-consumer-centric-approach-means-for-banks-and-businesses/?sh=1e9c62955f94
10. https://www.synctera.com/blog/banking-as-a-service-banks-25-billion-revenue-opportunity-in-fintech-banking
11. https://www.businessinsider.com/embedded-finance-explainer

References
Allen, F. (2012), “Trends in financial innovation and their welfare impact: an overview”, *European Financial Management*, Vol. 18 No. 4, pp. 493-514.

Anthemis (2019), “Embedded finance: the future of the economy”, Anthemis White Paper, London, available at: https://Tearsheet.Co/Wp-Content/Uploads/2019/11/Anthemis-Embedded-Finance-White-Paper-November-2019.Pdf

Frame, W.S. and White, L.J. (2004), “Empirical studies of financial innovation: lots of talk, little action?”, *Journal of Economic Literature*, Vol. 42 No. 1, pp. 116-144.

Gomber, P., Koch, J.A. and Siering, M. (2017), “Digital finance and FinTech: current research and future research directions”, *Journal of Business Economics*, Vol. 87 No. 5, pp. 537-580.

Hensen, J. and Kötting, B. (2022), “From open banking to embedded finance: the essential factors for a successful digital transformation”, *Journal of Digital Banking*, Vol. 6 No. 4, pp. 308-318.

Hoffman, C. (2022), “Embedded finance: why banks are moving towards it and its impact on trade finance”, *A Trade Finance Global Article*, available at: https://Www.Tradefinanceglobal.Com/Posts/Embedded-Finance-Why-Banks-Are-Moving-Towards-It-And-Its-Impact-On-Trade-Finance/
Ketterer, J.A. (2017), *Digital Finance: New Times, New Challenges, New Opportunities*, IDB-Inter American Development Bank, Washington, DC.

Mulye, D. (2021), “What is embedded finance and how it will change fintech”, *Finbox Blog*, available at: https://Finbox.In/Blog/What-Is-Embedded-Finance-And-How-It-Will-Change-Fintech-In-India/

Ohnishi, M. (2021), “New digital financial services offer the prospect of high customer retention – expectations for the growing trend of "embedded finance"”, A Mitsui and Co. Global Strategic Studies Institute Monthly Report, available at: https://Www.Mitsui.Com/Mgssi/En/Report/Detail/__Icsfiles/Afieldfile/2021/05/25/2103i_Ohnishi_E.Pdf

Olins, J. (2021), “How are small businesses using embedded finance? Business cloud media blog”, available at: https://Businesscloud.Co.Uk/Opinion/How-Are-Small-Businesses-Using-Embedded-Finance/

Ozili, P.K. (2018), “Impact of digital finance on financial inclusion and stability”, *Borsa Istanbul Review*, Vol. 18 No. 4, pp. 329-340.

Prasad, C. (2022), “Tapping into the potential of embedded finance”, *BSFI Blog*, available at: https://Bfsi.Economictimes.Indiatimes.Com/Blog/Tapping-Into-The-Potential-Of-Embedded-Finance/89662977

Principato, C. (2022), “How embedded finance will disrupt traditional financial services brands. Morning consult, media blog”, available at: https://Morningconsult.Com/2022/01/25/How-Embedded-Finance-Will-Disrupt-Traditional-Financial-Services-Brands/

Smith, J. and Wallraff, M. (2021), “Embedded finance: this decade’s largest creator of value”, Kore Fusion White Paper. 2021 Korefusion LLC, New York.

Teboul, L. and Anastasiou, A. (2020), “The embedded finance journey: innovation that differentiates the customer experience”, Goldman Sachs Transaction Banking White Paper.

Torrance, S. (2021), “Embedded finance: a $7 trillion game-changing opportunity for incumbents”, *A Report by Rainmaking*, available at: https://Discover.Rainmaking.Io/Hubfs/Embedded%20finance/Embedded%20finance%20report.Pdf?Hslang=En

Tufano, P. (2003), “Financial innovation”, in *Handbook of the Economics of Finance*, Vol. 1, pp. 307-335.

**Corresponding author**
Peterson K. Ozili can be contacted at: petersonkitakogelu@yahoo.com

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