# Embedded finance: assessing the benefits, use case, challenges and interest over time

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**Abstract**

There is little academic interest in embedded finance despite the fact that embedded finance is part of the on-going digital finance revolution. 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. Granger causality test and two-stage least square regression were used to assess interest over time in embedded finance. 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 uni-directional 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.

**Keywords:** Embedded finance, open finance, open banking, decentralized finance, financial innovation, FinTech, digital finance, BaaS, API.

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# 1. Introduction

Embedded finance 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, embedded finance is when non-financial companies or organizations include financial services as part of their services. Embedded finance 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. Embedded finance is all about integrating financial services into the products, services or processes of non-financial companies. Embedded finance 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 embedded finance 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, embedded finance 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 embedded finance 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. Embedded finance 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 and banks to their platforms through application programming interface (APIs)[1] (Hensen and Kötting, 2022). This is a major shift from the FinTech 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 FinTech business.

While embedded finance is popular among practitioners, academics have shown very little interest in embedded finance as a subject of research inquiry. Presently, there is no rigorous research or study about embedded finance in the academic literature. The scant research in this area creates an opportunity for academic and policy researchers to explore 1) how embedded finance can co-exist or transform traditional finance, 2) how embedded finance can improve the welfare of users, 3) how embedded finance might disrupt traditional banking, 4) whether embedded finance will increase or decrease systemic risk in the financial system, 5) how

[1] An API is a type of code used to simplify interactions between systems and services.

embedded finance 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 embedded finance. Extensive academic and policy research is needed in these areas in order to develop the academic and policy literature on embedded finance.

The purpose of this paper is to present an overview of embedded finance. The paper highlights the applications and use case examples of embedded finance. The paper also identifies the role of financial institutions in the embedded finance sector. The paper further highlights the benefits and challenges of embedded finance. The paper concludes with an analysis of 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. The discussion in this paper can provide valuable insights that can help economists, researchers, policy makers and academics gain a comprehensive understanding of embedded finance and what the embedded finance 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 embedded finance 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), Gomber, Koch and Siering (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 embedded finance. This section also highlights the role of financial institutions in embedded finance. Section 4 identifies some benefits and challenges of embedded finance. Section 5 presents the empirical analysis of interest over time data relating to embedded finance and related concepts. Section 6 concludes the paper.

## 2. Literature review

There are very few existing academic studies about embedded finance in the literature. The few academic studies in the literature suggest that academics have not paid attention to the emerging embedded finance opportunity. Much of the existing discussions about embedded finance 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 embedded finance partners. Teboul and Anastasiou (2020) suggest some criteria that should be taken into account by embedded finance partners. They suggest that embedded finance partners need to work with an embedded finance 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 embedded finance providers can support embedded finance partners as they grow.

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

Anthemis (2019) makes an important point about the existence of embedded finance and the need to scale embedded financial services through investment. Anthemis (2019) point out that many non-finance companies already have an embedded finance layer in their business but customers and investors have never noticed it or considered it. Anthemis (2019) called for more investment in embedded finance, and suggests that investment should be made into the embedded finance 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 embedded finance has been made possible by the unbundling of financial service functions brought about by technological progress and deregulation, and that embedded finance will become an irreversible trend. Ohnishi (2021) argues that embedded finance 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 embedded finance 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 embedded finance 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 embedded finance 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 embedded finance 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 embedded finance can change how financial services are consumed, but its transparency and how embedded finance 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 embedded finance 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 embedded finance and the use case examples of embedded finance. It also presents some global statistics about the embedded finance opportunity and the role of financial institutions in the embedded finance sector.

### 3.1. Applications of embedded finance

One of the biggest applications of embedded finance 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 embedded finance 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 embedded finance 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 embedded finance 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 embedded finance 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 (i) link more parties within the trade value chain, (ii) exchange funds at various points in the logistical trade process and (iii) ease some of the upfront burdens that financiers face in the trade finance process.

[2] https://www.weforum.org/agenda/2020/02/exporters-mind-trade-finance-gap/

### 3.2. Use case examples of embedded finance

Below are some use case examples of embedded finance.

**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

embedded finance. With embedded finance, 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:

- Embedded finance is worth $3.5 trillion in the global retail sector, according to research from cloud banking platform Mambu[5];
- The worldwide value of venture capital investments in embedded finance exceeded $4 billion in September 2021, according to data from statistia.com.[6]
- The retail sector will account for 49% of the embedded finance market within the next 10 years, according to a forecast by Mambu[7];
- The global opportunity for embedded finance 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]
- The estimated market value for embedded finance will be over $138 billion by 2026, according to a Forbes report;[9]
- The banking as a service (BaaS) market could grow to more than $25 billion in annual revenue in 2026, according to a forecast by Cornerstone advisor.[10]
- Embedded finance is expected to have an estimated market value of just under $230 billion by 2025 according to an estimate by Business Insider.[11]

[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

### 3.4. Role of financial institutions in embedded finance

Each financial institution need to decide on the exact role it will play in the embedded finance model. Generally, financial institutions have a role to play in application programming interface (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 embedded finance 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 embedded finance partners. Data controller, joint controller or processor roles should also be assigned appropriately. Financial institutions and the embedded finance 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 embedded finance. Financial institutions also need to provide customer data in accordance with existing regulations and laws. Financial institutions should offer banking as a service (BaaS) that non-finance companies can use to serve their customers. And since BaaS is often distributed to embedded finance partners through APIs, financial institutions should adopt strong risk management and compliance systems to prevent data breach when sharing data with embedded finance partners. Financial institutions will also need new business models to enable them compete and retain market share in the embedded finance model.

# 4. Benefits and challenges of embedded finance

This section highlights some benefits of embedded finance and the challenges of embedded finance.

### 4.1. Benefits of embedded financial services

One, embedded finance can increase revenue for parties involved in an embedded finance arrangement. Embedded finance 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. Embedded finance can also help non-finance companies establish new revenue streams. Two, embedded finance can make every non-finance company become a financial service provider. Embedded finance 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, embedded finance leads to a better payment experience. Embedded finance 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, embedded finance 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, embedded finance 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. Embedded finance presents an opportunity to give companies a competitive advantage in the market place. Embedded finance 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 embedded finance 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 embedded finance 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 embedded finance can make banks lose market share. Also, lack of partnership can limit progress in embedded finance. 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 (AML) and know-your-customer (KYC) regulations which can expose businesses to payment fraud.

# 5. Assessing interest in embedded finance

## 5.1. Data

Discussions about embedded finance often lead to discussions about open finance, open banking, financial innovation, digital finance, FinTech and decentralized finance. This indicates that these finance concepts may be interrelated. Accordingly, in this section, I assess the global interest in embedded finance and compare it with the global interest in open finance, open banking, financial innovation, FinTech, digital finance and decentralized finance. 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 internet 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 open finance (OPF), open banking (OPB) and digital finance (DF) over the period and a relatively low interest in information about embedded finance (EF), FinTech (FT) and decentralized finance (DCF) during the same period.

**Table 1. Interest over time: Descriptive statistics**

| 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 | 29.41 | 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 |

Annual mean of the interest over time data was obtained by taking the average of the monthly interest over time value for each year.

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 afterwards. Meanwhile, interest in digital finance and open banking rose significantly from 2013 onward while interest in embedded finance and decentralized finance remained low from 2004 to 2018 and began to rise in the post-2019 years. This indicates that interest in information about embedded finance began to gain traction from 2019 onward during the COVID-19 pandemic. Interest in FinTech rose significantly from 2014 up until 2021. Also, interest in digital finance, embedded finance, open finance, open banking, FinTech and decentralized finance 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 embedded finance during the 2004 to 2021 period.

Figure 1. Annual interest over time data for embedded finance, open finance, digital finance, open banking, financial innovation, FinTech and decentralized finance

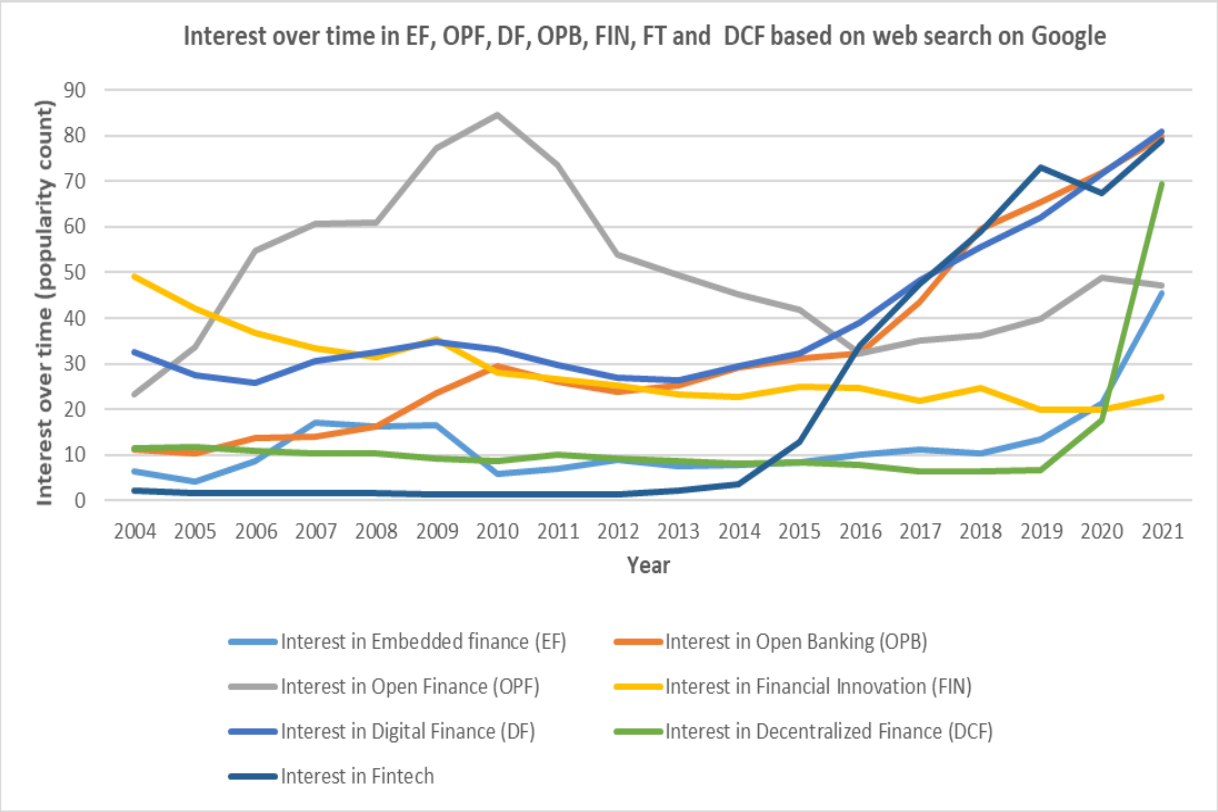
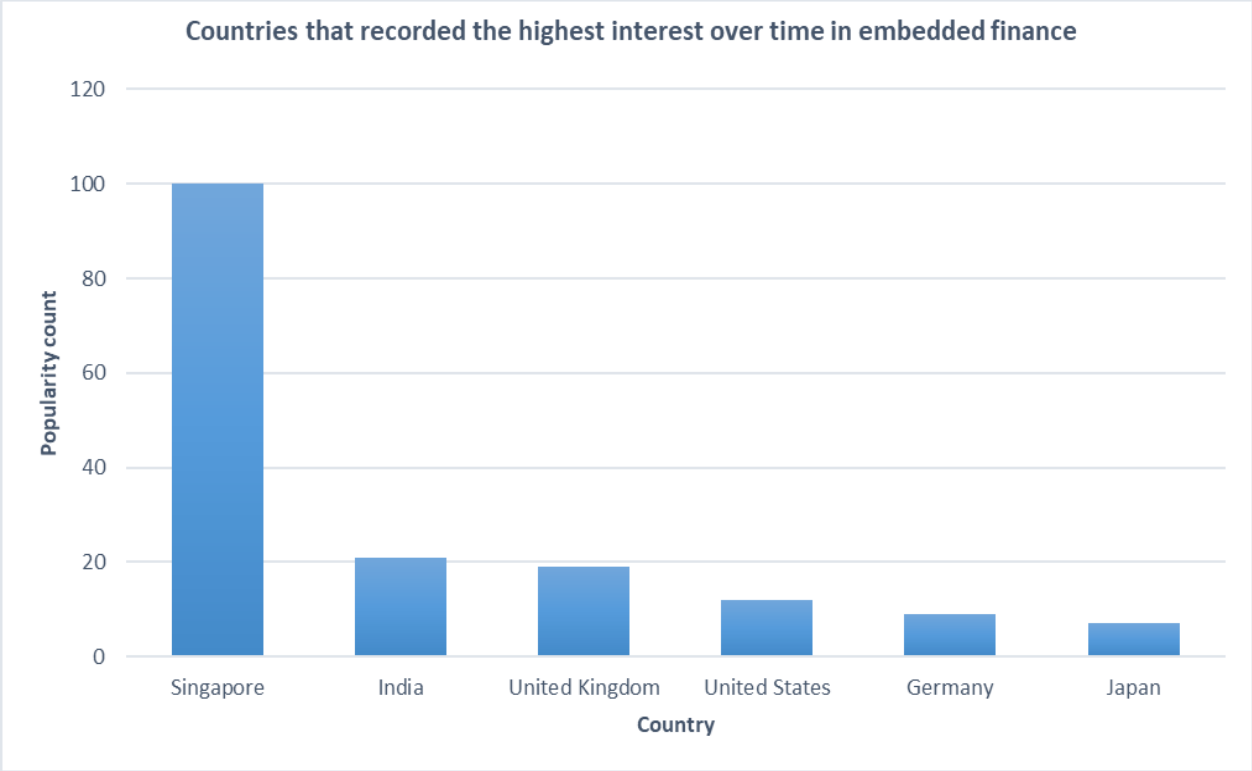


Figure 2. Countries that recorded the highest interest over time in embedded finance




### 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(FIN) and d(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 a bi-directional Granger causality between interest in information about embedded finance (EF) and interest in information about financial innovation (FIN). Also, there is one-way Granger causality between d(EF) and d(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 embedded finance and interest in information about open finance. Furthermore, there is one-way Granger causality between d(EF) and d(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 embedded finance and interest in information about digital finance. Overall, the result suggests that interest in information about embedded

finance causes interest in information about open finance, digital finance and financial innovation.

**Table 2. Augmented Dickey-Fuller test result for the variables**

| 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(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(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(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(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(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(FT) |
| Interest in information about Decentralized finance | DCF | -3.969*** | 0.002 | Does not have unit root. DCF is stationary. |

*** represents significance at the 1% level

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**Table 3. Pairwise Granger Causality Tests**

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

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

***, ** represent significance at the 1% and 5% level.

### 5.3. Determinant of interest in embedded finance

I perform a two-stage least square (2SLS) regression estimation to determine whether interest in decentralized finance, open finance, FinTech, open banking, financial innovation and decentralized finance are determinants of interest in embedded finance. 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 decentralized finance, open finance and FinTech lead to greater interest in information about embedded finance.

### 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 decentralized finance, open finance, open banking, financial innovation, FinTech and decentralized finance drives interest in embedded finance. 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 decentralized finance and open finance leads to greater interest in information about embedded finance.

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

| | (1) | (2) |
|---|---|---|
| | Dependent variable: EF | Dependent variable: EF |
| | Coefficient (t-statistic) | 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 |

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.

### 5.5. Additional analysis

In a separate analysis, I examine whether interest in embedded finance has a direct impact on interest in digital finance, decentralized finance, open finance, open banking, FinTech and financial innovation. In the analysis, interest in embedded finance (EF) is introduced as the explanatory variable while the interest in digital finance, decentralized finance, FinTech, open finance, open banking and financial innovation 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 embedded finance leads to greater interest in information about digital finance, decentralized finance, open banking and FinTech. Furthermore, I examine whether the lagged EM variable has a direct impact on interest in digital finance, decentralized finance, open finance, FinTech, open banking and financial innovation. The result in table 6 remain significant which indicates that greater interest in information about embedded finance leads to greater interest in information about digital finance, decentralized finance, FinTech and open banking. Finally, the Pearson correlation matrix reported in table 7 shows that interest in embedded finance has a positive and significant correlation with digital finance, decentralized finance, open banking and FinTech.

**Table 5. Effect of interest in embedded finance (EF) on interest in DF, DCF, FIN, OPB, 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 | 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) | -0.058 (-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 | 0.453 | 0.000 | 0.269 | 0.000 |
| J-statistic | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

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.

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**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*** | 2.792** | 28.828*** | 23.425*** | 49.789*** | 8.505*** |
| | (20.38) | (2.56) | (21.21) | (12.44) | (29.07) | (3.31) |
| Eft-1 | 0.738*** | 0.811*** | -0.026 | 0.836*** | 0.023 | 1.079*** |
| | (8.37) | (12.79) | (-0.33) | (7.62) | (0.23) | (7.21) |
| | | | | | | |
| R-squared | 24.76 | 43.43 | 0.05 | 21.39 | 0.02 | 19.62 |
| Adjusted 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 |

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.

**Table 7. Pearson correlation matrix for the variables**

| Variables | EF | DF | DCF | FIN | OPB | OPF | FT |
|---|---|---|---|---|---|---|---|
| EF | 1.000 | | | | | | |
| | ----- | | | | | | |
| | ----- | | | | | | |
| DF | 0.555*** | 1.000 | | | | | |
| | (9.76) | ----- | | | | | |
| | ((0.00)) | ----- | | | | | |
| DCF | 0.668**** | 0.558*** | 1.000 | | | | |
| | (13.15) | (9.85) | ----- | | | | |
| | ((0.00)) | ((0.00)) | ----- | | | | |
| FIN | -0.051 | -0.256*** | -0.049 | 1.000 | | | |
| | (-0.75) | (-3.87) | (-0.73) | ----- | | | |
| | ((0.45)) | ((0.00)) | ((0.46)) | ----- | | | |
| OPB | 0.488*** | 0.861*** | 0.493*** | -0.392*** | 1.000 | | |
| | (8.18) | (24.75) | (8.30) | (-6.24) | ----- | | |
| | ((0.00)) | ((0.00)) | ((0.00)) | ((0.00)) | ----- | | |
| OPF | 0.075 | -0.185*** | -0.028 | -0.027 | -0.151** | 1.000 | |
| | (1.11) | (-2.76) | (-0.42) | (-0.40) | (-2.24) | ----- | |
| | ((0.26)) | (0.00)) | ((0.67)) | ((0.68)) | ((0.02)) | ----- | |
| FT | 0.465*** | 0.883*** | 0.447*** | -0.315*** | 0.918*** | -0.351*** | 1.000 |
| | (7.69) | (27.62) | (7.32) | (-4.86) | (34.09) | (-5.49) | ----- |
| | ((0.00)) | (0.00)) | ((0.00)) | ((0.00)) | ((0.00)) | ((0.00)) | ----- |

***, ** represent significance at the 1% and 5% level. T-statistic is reported in single parenthesis.
P-value is reported in double parenthesis.

# 6. Conclusion

This paper presented an overview of embedded finance. It highlighted the applications, use case examples, benefits and challenges of embedded finance. 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 embedded finance showed that interest in embedded finance increased significantly during the COVID-19 pandemic. Singapore, India and the United Kingdom 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 uni-directional Granger causality between interest in information about embedded finance and interest in information about digital finance and open finance. The findings also show 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.

The implication of the empirical findings is that the embedded finance revolution is linked to developments in digital finance, decentralized finance and open banking and finance. This means that an embedded finance strategy needs to leverage on existing digital finance, decentralized finance and open banking 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 embedded finance opportunity.

Customers, practitioners, policy makers and researchers have a role to play in the embedded finance 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 constantly review the existing embedded finance 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 embedded finance innovations to thrive. Academics and researchers can use available data to establish relationships between embedded finance and economic aggregates to determine whether embedded finance developments have a positive or negative effect on the economy and society at large.

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

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