UNIVERSIDAD DE MURCIA

ESCUELA INTERNACIONAL DE DOCTORADO

Design a User Interface to Support Multiple Payment Systems in Web Browsers Supported by the Technology Acceptance Model

Diseño un Interfaz de Usuario para el Soporte de Múltiples Sistemas de Pago en los Navegadores Web Apoyado en el Modelo de Aceptación de la Tecnología

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2022

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Tesis Doctoral

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Murcia, septiembre de 2022

University of Murcia
Faculty of Computer Science

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Ph.D. Thesis

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Murcia, September 2022

A mis Padres, a Ti

Acknowledgments

First, I would like to start by expressing my deepest gratitude to my supervisors,

Dr. Antonio Ruiz Martínez,

&

Dr. Antonio Fernando Skarmeta Gómez,

who have guided and supported me unconditionally throughout this research adventure.

I am deeply grateful to my parents and my wife for their patience and understanding, for their unwavering support and, above all, for the LOVE they have given and helped me in many difficult situations. You are both an inspiration.

Finally, I'd want to express my gratitude to my sister and brothers. Special thanks also to my brother, Dr. Taieb Tounekti, and my wife, Dr. Marwa Ben Abdallah, who supported me during my Ph.D. studies.

الإهـــــــــــــــــداء

اهدي تخرجي إلى أبي الغالي رحمه الله وإلى أمّي الغالية الذي كانت سندي في مسيرتي

إلى من علّماني

نحـــــــــتَ شخصيتي

حفـــــــــرَ ذاكراتي

نســـــــــجَ أخلاقي

رســـــــــمَ طريقي

إلى من علّماني طريق الحياة

شكراً

"A todos los que me enseñan... a mi padre y a mi madre...
a mi esposa... a mi hermana y a mis hermanos...
a mis amigos
Gracias"

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Capítulo 1

Resumen

1.1 Motivación y objetivos

El comercio electrónico se ha convertido en un mercado de rápido crecimiento en la actualidad debido a la expansión experimentada durante la COVID-19. De hecho, para 2025 se espera que las actuales ventas mundiales de comercio electrónico al por menor hayan aumentado aproximadamente un 50%, alcanzando unos 7,4 mil millones de dólares (Statista, 2022) [1]. Los sistemas de pago electrónico han surgido como consecuencia de esta expansión del comercio electrónico, sustituyendo rápidamente el uso de sistemas de pago en efectivo. Se prevé que el mercado mundial de pagos digitales alcance los 8.686 miles de millones de dólares en 2025, según un informe de Mordor Intelligence [2].
Este crecimiento depende del uso de los sistemas de pago electrónico adecuados. En esta situación, han surgido una serie de soluciones para hacer frente a la cuestión de ofrecer diferentes sistemas para realizar un pago en Internet.

El aumento del uso de varios sistemas de pago electrónico, la aparición de otros nuevos y la búsqueda de sistemas que cubran las necesidades de los usuarios a la hora de realizar un pago en línea ha supuesto una importante cantidad de investigación para comprender los problemas que han surgido como resultado de estos desarrollos. Debido al número de sistemas de pago electrónico (móvil) disponibles en el mercado hoy en día, es habitual que un usuario pueda utilizar numerosos métodos de pago al realizar un pago en línea (por ejemplo, tarjetas de crédito, dinero electrónico, pagos sin contacto, monedero electrónico, PayPal, Bitcoin, etc.). El método de pago en línea más común, por el momento, es PayPal, con 426 millones de cuentas de usuario activas a finales del cuarto trimestre de 2021 y una previsión de 750 millones de usuarios para 2025 (eMarketer, 2022) [3]. Sin embargo, para aceptar el mayor número de transacciones financieras de clientes con diferentes orígenes, los comerciantes se esforzaron por ofrecer una gama de métodos de pago, al menos los más utilizados.

En este sentido, frente a la expansión de las soluciones de los sistemas de pago establecidos, se desarrollaron marcos de pago electrónico con el objetivo de proporcionar una gama de métodos de pago para completar la transacción de pago [4,61] y facilitar la

selección del método de pago (automático) a lo largo del proceso de pago [5].

Debido a esta necesidad, recientemente, el Consorcio World Wide Web (W3C) [6,7], a través de su Iniciativa de Pagos en la Web, está trabajando para comprender mejor las diferentes funcionalidades de los sistemas de pago, reducir las tasas de abandono de las tarjetas y fomentar la innovación en los pagos digitales. Están diseñando un conjunto de APIs de pago para incorporar a los navegadores web y que, a través de una interfaz de pago, permita a los usuarios realizar el pago de forma fácil y segura [8].

Es importante que esta interfaz de pago satisfaga las preferencias de los usuarios a la hora de seleccionar el método de pago adecuado cuando hay muchas alternativas disponibles. Por esta razón, se hizo necesario concentrarse en la identificación de las principales preocupaciones del sistema de pago electrónico (móvil) ((M)EPS) y los marcos de pago (PF)[9], a partir de investigaciones anteriores, que analizaron las características y preferencias del sistema de pago.

Para hacer frente a estos problemas, una parte de esta tesis identifica las características de los sistemas de pagos para comprender mejor los retos de (M)EPS, la FP y la aceptación de los usuarios, mientras que la otra parte sugiere el diseño de una nueva interfaz de pago que pueda soportar múltiples sistemas de pago, facilitar a los clientes en la elección de su método de pago preferido y aumentar la aceptación del servicio. Esta segunda parte es la cuestión principal que se aborda en esta tesis.

En consecuencia, como parte de la estrategia de trabajo de esta tesis de investigación, se plantean los siguientes objetivos:

Objetivo 1 (Obj1). Examinar los resultados de los estudios anteriores que evalúan las características tanto de los EPS como de los MPS para responder a las dos siguientes preguntas: 1) cómo han evolucionado estas características, y 2) cómo cambia su importancia relativa entre los dos tipos de sistemas de pago (EPS y MPS) para comprender el estado del arte de las características que soportan, determinar su influencia en la satisfacción del usuario y definir el diseño de la interfaz de pago.

Objetivo 2 (Obj2). Analizar y realizar una encuesta con participantes internacionales para determinar la actitud de los clientes hacia los pagos en línea, y descubrir experimentalmente los factores que influyen en la decisión de los clientes de realizar pagos en línea y los factores que influyen en la selección del método de pago preferido para realizar la compra en línea.

Objetivo 3 (Obj3). Diseño y evaluación de una interfaz de pago en el navegador web,

que admita varios métodos de pago y que tenga en cuenta las preferencias del usuario y facilite la elección del método de pago a utilizar.

Objetivo 4 (Obj4). Evaluación y análisis de las publicaciones más destacadas sobre los sistemas de pago electrónico (móvil) y las preferencias de los usuarios, con el fin de examinar las interacciones de estos componentes e investigar los elementos determinantes de la satisfacción de los usuarios de una interfaz que admite múltiples sistemas de pago, y que se tuvieron en cuenta para definir el diseño de la interfaz.

Los objetivos anteriores sirvieron para elaborar esta tesis, y su cumplimiento condujo a las conclusiones posteriores.

1.2 Resultados

En esta sección se presentan los resultados obtenidos durante esta tesis de forma detallada. En concreto, como se ilustra en la Tabla 1, los resultados de esta tesis han sido publicados en varias publicaciones científicas, como capítulos de libros y artículos en revistas de alto impacto. Los objetivos establecidos anteriormente están asociados a estos resultados y con el fin de alcanzar la meta introducida a lo largo de esta tesis.

En primer lugar, se realizó un estudio [10,11,61,62] de los resultados de investigaciones anteriores [12,60] sobre las características de los (M)EPS. El resultado es que hay que tener en cuenta nueve criterios a la hora de evaluar o desarrollar los (M)EPS. Entre ellos figuran la seguridad, el coste, la confianza, la privacidad, la autenticación, la confidencialidad, la integridad, el no repudio y el anonimato. Estas características parecen conectar los pagos móviles, los pagos electrónicos y los métodosde pago preferidos por los usuarios. Por lo tanto, es necesario seguir investigando para determinar las características de los servicios de los sistemas de pago más populares y examinar cuidadosamente esos servicios.

Tabla 1: Resultados obtenidos a lo largo de esta tesis.

Nro.	Resultado	Objetivo	Publicación
1	La identificación de las características más importantes que deben tenerse en cuenta al estudiar o desarrollar los (M)EPS, y los pagos preferidos por los clientes. Entre ellas se encuentran la seguridad, el coste, la confianza, la privacidad, la autenticación,la confidencialidad, la integridad, el no repudio y el anonimato.	**Obj1**	[60]
2	Identificación de las preferencias del usuario entre los muchos método s de pago que se admiten o están disponibles para él.	**Obj2**	[61]
3	Se han constatado fuertes relaciones entre los navegadores webs más útiles (principalmente Chrome, Microsoft Edge y Safari) y las características y preferencias del método de pago.		
4	El usuario puede estar motivado para guardar información en el navegador de Internet, ya que el almacenamiento de información tiene un impacto significativo en el método de pago elegido.		
5	Las opciones de pago más comunes para los dispositivos de escritorio y móviles son MasterCard, Visa y PayPal.		
6	Los encuestados prefieren Google Chrome como el navegador web que soporta sus opciones de pago en línea preferidas.		
7	Identificación de las funcionalidades importantes a la hora de utilizar el (M)EPS, así como el método de pago preferido por el usuario, incluyendo la seguridad, la facilidad de uso, la confidencialidad, la utilidad, el almacenamiento de la información, la selección automática del mejor método de pago,la comodidad, el tiempo, la precisión y los costes/tasas de las transacciones.		
8	Identificación de las características del método de pago delusuario para facilitar el proceso de pago.	**Obj3**	[62]
9	Creación del diseño de una nueva interfaz de pago web que está sustancialmente mejor evaluada que la interfaz ofrecida por el navegador web Google Chrome para permitir el pago cuando los usuarios admiten varios métodos de pago.		
10	Existe una relación significativa entre las características demográficas (sexo, edad y nivel educativo) y la intención de utilizar la nueva interfaz de pago por Internet.		

11	Identificación de las características significativas (facilidad de uso, utilidad, seguridad, confidencialidad, privacidad, preferencias de los métodos de pago, diseño de la interfaz visual, credibilidad y conveniencia) que influyen en la aceptación de una nueva interfaz de pago del navegador web.		
12	El pago electrónico, el pago por móvil, la confianza, la facilidad de uso, la seguridad y el riesgo percibido influyen en la aceptación de una nueva interfaz de pago web con varias opciones de pago.	**Obj4**	[63]
13	La importancia de analizar la relación entre las diferentes cuestiones relacionadas con la (M)EPS y la FP y la creación de una nueva interfaz de pago en la web para permitir los pagos cuando los usuarios admiten varios métodos de pago, basándose en las preferencias y la aceptación del usuario.		
14	Determinación de las publicaciones más importantes, los autores prolíficos, los institutos y los campos de estudio clave para evaluar el desarrollo del tema de investigación de la (M)EPS y la PF.		
15	El estudio de las preferencias de los consumidores y la aceptación de nuevos sistemas y marcos de pago, así como la forma en que la confianza y la seguridad pueden adaptarse a las preferencias de los usuarios, es un área de investigación en desarrollo.		
16	Los gobiernos deben establecer estrategias más eficaces y oportunas para gestionar adecuadamente el comercio electrónico y el pago en línea políticas (e/m-pago).		

A continuación, se llevó a cabo un estudio empírico para llenar el vacío de la investigación y cumplir el objetivo del usuario de seleccionar el método de pago preferido y determinar las características que le animan a pagar en línea [13,14]. Para ello, se tuvieron en cuenta cuatro componentes (en concreto, la descripción demográfica, la elección del navegador web, el método de pago más preferido utilizando el ordenador de sobremesa y el teléfono móvil, y las características del contribuyente de conocimientos).

Además, se midió la relación entre el método de pago preferido y las numerosas características identificadas. Se realizó una encuesta y un análisis estadístico para cumplir los objetivos del estudio. Según los resultados, los métodos de pago más populares en ordenadores de sobremesa y dispositivos móviles fueron Mastercard, Visa y PayPal. Características de pago como la seguridad, la facilidad de uso, la privacidad, la utilidad, el almacenamiento de información, la selección automática de la mejor opción de pago, la comodidad, el tiempo, la precisión y el coste/tasa de la transacción han recibido una atención especial al utilizar (M)EPS.

Por otra parte, para satisfacer la intención de los usuarios de (M)EPS, se diseñó una nueva interfaz de pago en el navegador web que admite múltiples sistemas de pago y tiene en cuenta las preferencias de los usuarios [61]. Basándonos en nuestra investigación de la literatura sobre pagos y en la interfaz de pago que ofrece el navegador web Google Chrome (GCWB), en los resultados del análisis anterior y en una evaluación realizada con 266 usuarios, hemos llegado a la siguiente conclusión: El diseño de la nueva interfaz de pago puede admitir muchos sistemas de pago, ayudar a los clientes a seleccionar el método de pago elegido y aumentar la aceptación del servicio. Esta nueva interfaz también permite al usuario personalizar su configuración para admitir varios métodos de pago y facilitar el procedimiento de pago en línea.

Para alcanzar este objetivo se requieren varios factores, siendo la seguridad el de coeficiente más significativo relacionado con la percepción de los usuarios de los métodos de pago por interfaz, seguido de la facilidad de uso y la utilidad.

Nuestro estudio, por otra parte, identifica las preferencias del usuario a la hora de seleccionar una interfaz de pago para agilizar el proceso de pago, así como las características que más aprecia durante una transacción de pago en línea. Muchos clientes de comercio electrónico utilizarán una interfaz de pago fácil de usar para todas las transacciones de pago en línea, lo que demuestra que la necesidad de una interfaz de pago intuitiva sigue siendo pertinente y necesaria.

La propuesta de diseño de una interfaz de pago en línea supone una aportación teórica al establecer un modelo para medir la satisfacción del usuario y su disposición a adoptar una nueva interfaz de pago. A continuación, basándonos en los resultados de la encuesta, realizamos un estudio para demostrar que la interfaz de usuario propuesta es aceptable para los individuos. Los resultados de nuestra evaluación sugieren que la interfaz propuesta es apreciada, sencilla y satisface las necesidades de los usuarios [61].

Otro resultado a destacar es que la aceptación de una nueva interfaz de pago para un navegador de Internet depende de los siguientes factores: facilidad de uso, utilidad, seguridad, privacidad, confidencialidad, preferencias de métodos de pago, diseño visual de la interfaz y credibilidad.

En este sentido, nuestras conclusiones sirven de base fundamental para futuras investigaciones en diversos contextos sobre los factores que influyen en la intención de los consumidores de utilizar el (M)EPS. Este es el resultado de una amplia investigación sobre el (M)EPS. De hecho, en las investigaciones publicadas se pueden encontrar varios trabajos sobre diversos aspectos de los (M)EPS [4,10]. Algunos estudios se han centrado en temas

específicos, como la PI [61], el TAM [15], la PF [9,12] y las preferencias y aceptación de los usuarios [16,17,61]. Debido a la importante investigación realizada en este tema, consideramos que es necesario integrar las investigaciones e identificar los temas de estudio y los problemas importantes.

Para ello se ha realizado un análisis bibliométrico [18,19,20,63]. Su objetivo es poner de manifiesto las lagunas de investigación que prevalecen en el tema de estudio y proporcionar a los académicos los recursos para investigar los nuevos temas de investigación reconocidos. La investigación indica que el pago electrónico, el pago por móvil, la confianza, la facilidad de uso, la seguridad y el riesgo percibido tienen un efecto importante en el método de pago. Además, los términos de búsqueda "seguridad", "facilidad de uso", "riesgo percibido", "confianza", "adopción" e "intención de uso", así como el "modelo de aceptación de la tecnología (TAM)", están ganando importancia como términos de búsqueda en la literatura académica. Esto pone de manifiesto la importancia de investigar la interacción entre estos componentes.

El análisis bibliométrico demuestra la creciente importancia de nuestro tema de estudio a lo largo del tiempo. En consecuencia, los resultados que se presentan en esta sección ofrecen una visión general del enfoque de trabajo empleado para cumplir los objetivos previamente establecidos. Esta visión se amplía a continuación en el capítulo 3, que abarca los métodos para introducir la solución sugerida mediante un modelo de investigación teórico y un marco exhaustivo para evaluar la satisfacción del usuario con las interfaces de pago que admiten múltiples métodos de pago. Nuestra investigación nos permite compartir nuestros hallazgos con el Grupo Web de Pagos del W3C con el fin de mejorar el uso de los sistemas de pago en línea, ayudar a muchos usuarios a elegir los sistemas de pago adecuados y hacer que numerosos métodos de pago estén disponibles en la Web.

Debido a la actual situación mundial COVID-19, los individuos están empezando a utilizar (M)EPS con más frecuencia que en el pasado. Por lo tanto, las preocupaciones y preferencias demográficas pueden cambiar como resultado del aumento del uso de (M)EPS. De hecho, Stavins, in 2017 [21], en su investigación confirma el efecto de las características demográficas en las preferencias de pago móvil del usuario. Por lo tanto, sería beneficioso realizar más investigaciones sobre el número de sistemas de pago empleados, las características de los métodos de pago en línea y las preferencias de los usuarios.

1.3 Conclusiones y Trabajos Futuros

Los sistemas de pago electrónicos (móviles) son un tema importante que ha cobrado mucho interés, especialmente con la situación actual; la aparición de COVID-19. Por lo tanto, es crucial proporcionar una interfaz de pago en línea que el cliente encuentre fácil de manejar y que responda a su solicitud y selección para su pago en línea.

Para ello, en primer lugar, revisamos los trabajos de investigación anteriores que se han centrado en las características de los (M)EPS. Tras un profundo análisis de las diferentes características que las identifican, se ha revelado que la seguridad, la confianza, la privacidad, el coste, la autenticación, la confidencialidad, la integridad y el anonimato son las características más importantes que el cliente considera mientras utiliza un sistema de pago en línea.

Para examinar en profundidad estos factores, se estableció un trabajo de investigación para descubrir la intención y el uso de los (M)EPS por parte del cliente al realizar una compra online. Como resultado, determinamos las preferencias de los usuarios cuando se enfrentan a múltiples (M)EPS, y qué factores influyen en su elección del método de pago preferido. Los resultados muestran que los usuarios se basan en la utilidad, el coste, la seguridad, la privacidad y la comodidad a la hora de elegir sus sistemas de pago preferidos. El mayor porcentaje de preferencias de los usuarios se registra en la seguridad percibida y la facilidad de uso. Las dimensiones demográficas (sexo, edad y nivel de estudios) muestran una relación significativa con el método de pago elegido. MasterCard y PayPal son los métodos de pago preferidos, y Visa ocupa el tercer lugar como método de pago preferido, pero tiene un bajo porcentaje de usuarios que afirman su uso.

Es interesante señalar que se ha revelado que los navegadores tienen una fuerte relación significativa con las preferencias y características del método de pago. La existencia de este vínculo motiva la realización de nuevos estudios para explorar la conexión. Safari está vinculado con la característica "coste", los usuarios utilizan Safari debido su percepción de tarifas más bajas. Mientras que Chrome se considera más seguro, según los encuestados. La gente utiliza Chrome debido a la seguridad. El navegador Microsoft Edge se asocia con la facilidad de uso y la simplicidad. Por lo tanto, estas dos características (facilidad de uso y simplicidad) son importantes a la hora de seleccionar el navegador preferido.

Basándonos en los resultados de nuestras investigaciones anteriores [10,11,61,62], hemos propuesto una interfaz de pago para los pagos en línea como siguiente paso. Se ha comprobado que la interfaz propuesta satisface las necesidades del usuario. En concreto, se ha acordado que las principales características de la interfaz de pago son 8 (es decir, facilidad de uso y utilidad,

seguridad, confidencialidad, privacidad, preferencias de métodos de pago, diseño visual de la interfaz y credibilidad). Los resultados muestran que los usuarios jóvenes con un alto nivel de educación están más interesados en las nuevas tecnologías y están más dispuestos a utilizar la nueva interfaz de pago propuesta que los demás.

Concluimos nuestra investigación con un análisis bibliométrico. Se trata de la primera investigación bibliométrica que incluye los (M)EPS, la interfaz de pago, el modelo de aceptación de la tecnología (TAM) y la aceptación del usuario. Los resultados muestran que, además del interés de los países desarrollados por los sistemas y plataformas de pago electrónico y móvil, los países en desarrollo se centran en mejorar su análisis de los (M)EPS, a medida que aumenta su uso. El TAM, el riesgo percibido, la confianza y la seguridad son aspectos que se plantean. Además, las conclusiones ofrecen un análisis exhaustivo de los (M)EPS, las interfaces de pago, el TAM, la FP, las preferencias de los usuarios y los estudios de aceptación, que serán de gran interés para académicos y profesionales.

Finalmente, como trabajo futuro, se requiere que los resultados obtenidos en el diseño de la interfaz de pago sean validados a través de un prototipo que permita al usuario interactuar con la interfaz y, así, obtener una mejor retroalimentación para la satisfacción de las necesidades del usuario. También consideramos que los gobiernos deben adoptar métodos más eficientes y oportunos para gestionar el comercio electrónico y las normas de pago en línea (e/m-payment). Las políticas gubernamentales, en general, prevén futuras tendencias de crecimiento o sectores elegidos, lo que fomentará la formulación y el crecimiento de la investigación en esta área.

1.4 Estructura de la Tesis

Esta tesis está estructurada de acuerdo con el compendio publicado. Así, el capítulo 1 comienza con una introducción en español que expone la motivación y los objetivos iniciales de la investigación. Este capítulo también resume los resultados obtenidos tras la realización de esta tesis, así como su relación con los objetivos previamente establecidos. Del mismo modo, el capítulo 2 incluye una versión en inglés del resumen del capítulo 1.

El capítulo 3 se centra en las principales preocupaciones que motivaron el desarrollo de esta tesis. También se expone la solución propuesta para hacer frente a dicha necesidad, así como los múltiples métodos de pago que la incluyen. A continuación, el capítulo 4 contiene las tres publicaciones que componen esta tesis y que se presentan brevemente a continuación:

- *Users Supporting Multiple (Mobile) Electronic Payment Systems in Online Purchases: An Empirical Study of Their Payment Transaction Preferences*.

Siguiendo la metodología de estudio utilizada durante este trabajo de investigación, este artículo se centra en el objetivo de identificar la actitud del cliente hacia el pago online, exponiendo su intención de elegir el método de pago preferido en función de un conjunto de características. Para ello, se consideraron cuatro componentes (es decir, la descripción demográfica, la elección del navegador web, el método de pago más preferido utilizando el ordenador de sobremesa y el teléfono móvil, y las características de los contribuyentes al conocimiento). Para alcanzar el objetivo de la investigación, se realizó una encuesta y un análisis estadístico. MasterCard, Visa y PayPal fueron los métodos de pago más populares en ordenadores de sobremesa yteléfonos móviles, respectivamente. La facilidad de uso y la seguridad de estas opciones de pago pueden ser las principales razones por las que nuestros participantes las eligen.

- *Users' Evaluation of a New Web Browser Payment Interface for Facilitating the Use of Multiple Payment Systems*. Esta publicación se centra en la necesidad de proporcionar soluciones diseñadas para responder a la intención del usuario en (M)EPS. Se propone una nueva interfaz de pago para el navegador web, que tiene en cuenta las preferencias del usuario para soportar múltiples sistemas de pago y le permite especificar qué requisitos debe cumplir. En consecuencia, debido a una mejor evaluación con respecto a la interfaz de pago del navegador web Chrome, la nueva interfaz de pago puede dar cabida a diversos sistemas de pago, facilitará los usuarios la elección de su método de pago preferido y aumentar la aceptación del servicio. Además, se revisa la solución sugerida en una encuesta y se presenta un nuevo diseño para la interfaz de pago web propuesta. La seguridad es el mayor coeficiente significativo relacionado con la percepción de los usuarios sobre los métodos de pago de la interfaz, seguido de la facilidad de uso y la utilidad.
- *Investigación en sistemas de pago electrónicos y móviles: Un análisis bibliométrico.* Esta publicación pretende poner de manifiesto las lagunas de investigación que existen en los sistemas de pago electrónico y móvil y proporcionar a los académicos los recursos necesarios para investigar los nuevos problemas que se han puesto de manifiesto. Para colmar esta laguna, se ha realizado un análisis bibliométrico. Además, esta estrategia se implementa y evalúa utilizando una sintaxis de búsqueda de temas basada en el análisis de las siguientes palabras clave: sistema de pago electrónico, sistema de pago móvil, pago electrónico m-payment, marco de pago, interfaz de pago, preferencia, aceptación, satisfacción y modelo de aceptación de la

tecnología (TAM). Según los resultados obtenidos, el estudio sirve de marco para futuras investigaciones, y este análisis bibliométrico demuestra la importancia de nuestro tema de investigación.

La bibliografía de esta tesis se incorpora en el capítulo 5, e incluye las publicaciones indicadas en el apartado 5.1, así como otras publicaciones adicionales generadas durante el desarrollo de esta tesis (apartado 5.2).

Chapter 2

Abstract

2.1 Motivation & Objectives

E-commerce has become a rapidly growing market today due to the expansion experimented during COVID-19. Indeed, by 2025, it is expected that the current global retail e-commerce sales would have increased by approximately 50%, reaching around $7.4 trillion (Statista, 2022)[1]. Electronic payment systems have emerged as a consequence of this expansion of e-commerce, rapidly replacing the use of cash payment systems. The worldwide market for digital payments was predicted to reach USD 8686 billion by 2025, according to a report by Mordor Intelligence [2]. This growth is dependent on the usage of appropriate electronic payment systems. In this situation, a number of solutions have emerged to cope with the issue of offering different solutions to make a payment on the Internet.

The increased usage of several electronic payment systems, the emerge of new different ones and the search of systems that cover users' needs when making an online payment has supposed a significant amount of research to understand the problems that have come up as a result of these developments. Due to the number of (mobile) electronic payment systems available on the market today, it is typical for a user to be able to use numerous payment methods while making an online payment (e.g. credit cards, electronic cash, contactless payments, electronic wallet, PayPal, Bitcoin, and so on). The most common method of online payment, at the moment, is PayPal with 426 million active user accounts at the end of Q4 2021 and an anticipated 750 million users by 2025 (eMarketer, 2022) [3]. However, in order to accept the most financial transactions from customers with different backgrounds, merchants made an effort to provide a range of payment methods, at least the most commonly used ones.

In this sense, faced with the expansion of established payment system solutions, electronic payment frameworks were developed with the goal of providing a range of payment methods to complete the payment transaction [4,61] and making payment method selection (automatic) easier throughout the payment process [5].

Due to this need, recently, the World Wide Web Consortium (W3C) [6,7], through its Web Payment Initiative, is working to better comprehend the different payment system functionalities, reduce card abandonment rates, and fostering digital payment innovation. They are designing a set of payment APIs to be incorporated into web browsers and that, through a payment interface allows users to make payment in an easy and secure way[8].

It is important that this payment interface satisfies the goals of user preferences in selecting the appropriate payment method when many alternatives are available. Therefore, it became necessary to concentrate on identifying the main concerns of (mobile) electronic payment system ((M)EPS) and payment frameworks (PF) [9], from previous research, which analyzed the payment system characteristics and preferences.

To cope with these issues, one part of this thesis identifies payment system characteristics to better understand the challenges of (M)EPS, PF, and user acceptance, while another part suggests the design of a new payment interface solution that may support multiple payment systems, support customers in choosing their preferred payment method, and increase service acceptance. This second part it is the main issue to be addressed in this thesis.

Consequently, as part of the work strategy for this research thesis, the following objectives are outlined:

Objective 1 (Obj1). Examine the findings of previous studies assessing the characteristics of both EPS and MPS to answer the following two questions: 1) how these characteristics have evolved, and 2) how their relative importance changes across the two types of payment systems (EPS and MPS) to understand the state of the art of supporting characteristics, determine their influence on user satisfaction, and define the payment interface design.

Objective 2 (Obj2). Analyses and conduct a questionnaire survey with international participants to determine the customer's attitude toward online payments, and to experimentally discover the factors that influence customers' decisions to make online payments and the factors that influence in the selection of the preferred payment method to make purchase online.

Objective 3 (Obj3). Design and evaluation of a web browser payment interface, which supports several payment methods and that considers user prefe facilitate the choice of the payment method to be used.

Objective 4 (Obj4). Evaluation and analysis of the most prominent publications on (mobile) electronic payment systems and user preferences, in order to examine the interactions

of these components and investigate user satisfaction determinants of an interface that supports multiple payment systems, which were considered to define the interface design.

The prior objectives served to elaborate this thesis, and their accomplishment led to the subsequent findings.

2.2 Results

This section presents the results obtained during this thesis in a detailed way. Namely, as illustrated in Table 1, the findings of this thesis have been published in several scientific publications, such as book chapters and articles in high-impact journals. The objectives established previously are associated with these results and for the purpose of achieving the goal introduced throughout this thesis.

A literature study [10,11,61,62] was performed on the subject based on the findings of previous research [12,60] on the characteristics of (M)EPS. As a result, nine criteria should be considered while assessing or developing (M)EPS. Among them include security, cost, confidence, privacy, authentication, confidentiality, integrity, non-repudiation, and anonymity. These features appear to connect mobile payments, electronic payments, and user preferred payments methods. Therefore, further research was required to determine the features of the most popular payment system services and carefully examine those services.

Table 1: Results accomplished throughout this thesis.

N°	Result	Objective	Publication
1	Identification of the most important characteristics must be considered while studying or developing (M)EPS, and customer-preferred payments. These include security, cost, trust, privacy, authentication, confidentiality, integrity, non-repudiation, and anonymity.	**Obj1**	[6o]
2	Identification of the user's preferences among the many payment methods that are supported or available to him.	**Obj2**	[61]

3	Strong relationships were stated between the most useful web browsers (mainly Chrome, Microsoft Edge and Safari) and the payment method features and preference.		
4	The user may be motivated to save information in the internet browser since storing information has a significant impact on the payment method chosen.		
5	The most common payment options for desktop and mobile devices are MasterCard, Visa, and PayPal.		
6	Respondents preferred Google Chrome as the web browser that supports their preferred online payment options.		
7	Identification of the important functionalities when using (M)EPS, as well as the user's preferred payment method, including security, ease of use, confidentiality, usefulness, information storage, automatic selection of the best payment method, convenience, timing, accuracy, and transaction costs/fees.		
8	Identification of the user's payment method characteristics to facilitate the payment process.		
9	Creation of the design of a new web payment interface that is substantially better evaluated than the interface offered by the Google Chrome Web browser to enable payment when users support multiple payment methods.		
10	There is a significant relationship between demographic characteristics (gender, age, and education level) and the intention to use the new web payment interface.	**Obj3**	[62]
11	Identification of the significant features (ease of use, usefulness, security, confidentiality, privacy, payment method preferences, visual interface design, credibility, and desirability) that influence the acceptance of a new web browser payment interface.		
12	Electronic payment, mobile payment, trust, ease of use, security, and perceived risk have influence in the acceptance of a new web payment interface with several payment options.	**Obj4**	[63]

13	The importance of analyzing the relationship between different issues related to (M)EPS and PF and creating a new web payment interface to enable payments when users support several payment methods, based on user preferences and acceptance.		
14	Determination of the most important publications, prolific authors, institutes, and key study fields to assess the development of the (M)EPS and PF research topic.		
15	The study of consumer preference and acceptance of new payment systems and frameworks, as well as how trust and security may adapt to user preferences, is a developing area of research.		
16	Governments must establish more efficient and timely strategies to appropriately handle e-commerce and online payment policies (e/m-payment).		

Next, an empirical study was carried out to fill the research gap and meet the user's goal of selecting the preferred payment method and determining the characteristics that encourage them to pay online [13,14]. For that purpose, four components (i.e., demographic description, web browser choice, most preferred payment method using desktop and mobile phones, and the knowledge contributor characteristics) were considered.

Furthermore, the relationship between the preferred payment method and the many identified characteristics was measured. A survey was done and a statistical analysis was performed to meet the study's objectives. According to the findings, the most popular payment methods on desktops and mobile devices were Mastercard, Visa, and PayPal. Payment features such as security, ease of use, privacy, usefulness, storing information, the automatic selection of the best option of payment, convenience, timing, accuracy, and transaction received special attention when using (M)EPS.

Otherwise, to meet user intent in (M)EPS, a new web browser payment interface that supports multiple payment systems and considers user preferences was designed [61]. Based on our investigation of the payment literature and the payment interface offered by the Google Chrome web browser (GCWB), the results of the previous analysis, and an assessment made with 266 users, we have reached the following conclusion: The design of the new payment interface may support many payment systems, aid customers in selecting their chosen payment method, and increasing the acceptance of the service. This new interface also allows the user to

customize their settings in order to support a number of payment methods and ease the online payment procedure.

Several factors are required to reach this goal, with security having the most significant coefficient related to user perception of interface payment methods, followed by ease of use and usefulness.

Our study, on the other hand, identifies user's preferences when selecting a payment interface to expedite the payment process, as well as the characteristics that he/she appreciates the most during a payment transaction online. Many e-commerce customers will use a user-friendly payment interface for all online payment transactions, demonstrating that the need for an intuitive payment interface is still relevant and necessary.

The proposed design of an online payment interface provides a theoretical contribution by establishing a model for measuring user satisfaction and willingness to adopt a new payment interface. Then, based on survey results, we conducted a study to demonstrate that the suggested user interface was acceptable by individuals. The results of our assessment suggest that the proposed interface is appreciated, simple, and fulfills the users' needs [61].

Another result to point out is that the acceptance of a new payment interface for an Internet browser is dependent on the following factors: ease of use, usefulness, security, privacy, confidentiality, payment method preferences, visual interface design, and credibility.

In this regard, our findings serve as a critical foundation for future research in various contexts into factors influencing consumers' intentions to use (M)EPS. This is the result of an extensive research on (M)EPS. Indeed, several papers on various aspects of (M)EPS can be found in the published research [4,10]. Some studies have concentrated on specific topics such as PI [61], TAM [15], PF [9,12], and user preferences and acceptance [16,17,61]. Because of the significant research conducted in this subject, we consider there is a need to integrate the research and identify the themes of study and important problems.

A bibliometric analysis was done to achieve this requirement [18,19,20,63]. It aims to highlight the prevalent research gaps in the subject of study and provide academics with the resources to investigate newly recognized research topics. The research indicates that electronic payment, mobile payment, trust, ease of use, security, and perceived risk have a major effect on the payment method. In addition, the search terms, "security", "ease of use", "perceived risk", "trust", "adoption", and "intention to use," as well as "technology acceptance model (TAM)," are gaining prominence as search terms in academic literature. This significance of investigating the interaction between these components.

The bibliometric analysis demonstrates the increasing significance of our study topic

over time. Consequently, the outcomes reported in this section provide an overview of the work approach employed to fulfill the previously established goals. This vision is then expanded upon in Chapter 3, which covers methods for introducing the suggested solution using a theoretical research model and a thorough framework for assessing user satisfaction with payment interfaces that support multiple payment methods. Our research allows us to share our findings with the W3C Payments Web Group in order to improve the use of online payment systems, assist many users in choosing the appropriate payment systems, and make numerous payment methods available on the Web.

Due to the current global COVID-19 situation, individuals are beginning to use (M)EPS more frequently than in the past. Thus, demographic concerns and preferences may shift as a result of increased (M)EPS use. Indeed, Stavins, in 2017 [21], in his research confirms the effect of demographic characteristic on the user mobile payment preferences. Therefore, it would be beneficial to do more reseach into the number of payment systems employed, the features of online payment methods, and user preferences.

2.3 Conclusions and Future Work

Mobile and electronic payment systems are an important topic that has gained a lot of interest, especially with the current situation; the appearance of COVID-19. Thus, it is crucial to provide an online payment interface that the customer finds easy to handle and responds to his/her requesting and selecting for his/her online payment.

For this purpose, firstly, we reviewed previous research works that have focused on (M)EPS features. After a deep analysis of the different characteristics that identify them, it has been revealed that security, trust, privacy, cost, authentication, confidentiality, integrity, and anonymity are the most important features that the customer considers while using an online payment system.

To examine deeply these factors, research work was established to discover the customer intention and use of (M)EPS while performing an online purchase. As a result, we determined user preferences when faced with multiple (M)EPS, and which factors influence his/her choice of preferred payment method. The findings exhibit that users rely on usefulness, cost, security, privacy, and convenience while choosing their preferred payment systems. The highest percentage of user’s preferences is registered for perceived security and ease of use. The demographic dimensions (gender, age, and level of education) show a significant relationship with the payment method chosen. MasterCard and PayPal are the

most preferred payment method, and Visa comes in third place as a preferred payment method, but it has a low percentage of users that affirm its use.

It is interesting to point out that it has been revealed that browsers have a strong significant relationship with payment method preferences and features. The existence of this link motivates further studies to explore connection. Safari is linked with the feature “cost”, users who use Safari because of the lower fees. While Chrome is considered more secure, according to respondents. People use Chrome because of the security feature. Microsoft Edge browser is associated with ease of use and simplicity. Hence, these two features (ease of use and simplicity) are important when selecting a preferred browser.

Based on our previous research findings [10,11,61,62], we proposed a payment interface for online payments as the next step. The proposed interface has been found to meet the needs of the user. Namely, 8 characteristics are agreed to be the primary interface payment features (i.e. ease of use and usefulness, security, confidentiality, privacy, payment method preferences, visual interface design, and credibility). The findings show that young users with a high level of education are more interested in new technologies and are more willing to use the proposed new payment interface than others.

We concluded our investigation with a bibliometric analysis. It represents the first bibliometric research that included (M)EPS, payment interface, technology acceptance model (TAM), and user acceptance. The findings show that, in addition to developed countries' interest in electronic and mobile payment systems and platforms, developing countries are focused on improving their analysis of (M)EPS, as their usage grows. The TAM, perceived risk, trust, and security are all looming. In addition, the findings give a comprehensive analysis of (M)EPS, payment interfaces, TAM, PF, user preferences, and acceptance studies, which will be of considerable interest to academics and practitioners.

Finally, as future work, it is required that the results obtained in the design of the payment interface are validated through a prototype that allows user to interact with the interface and, thus, obtain better feedback for the satisfaction of user’s needs. We also consider that governments must adopt more efficient and timely methods of managing e-commerce and online payment standards (e/m-payment). Government policies, in general, foresee future growing trends or chosen sectors, which will encourage the formulation and growth of research on this area.

2.4 Thesis Structure

This thesis is structured in accordance with the published compendium. Accordingly, Chapter 1 begins with an introduction in Spanish that outlines the research's motivation and initial goals. This chapter also summarizes the results obtained following the completion of this thesis, as well as their relationship to the previously established objectives. Similarly, Chapter 2 includes an English version of the Chapter 1 summary.

Chapter 3 focuses into the major concerns that prompted the development of this thesis. The proposed solution to address such a need is also outlined, as there are the multiple payment methods that include it. Then, Chapter 4 contains the three publications that comprise this thesis and that are briefly presented next:

- *Users Supporting Multiple (Mobile) Electronic Payment Systems in Online Purchases: An Empirical Study of Their Payment Transaction Preferences*. Following the study methodology used during this research work, this article focuses on the aim to identify the customer's attitude toward online payment, exposing his/her intention to choose the preferred payment method based on a set of characteristics. Accordingly, four components (i.e., the demographic description, the choice of web browser, the most preferred payment method using desktop and mobile phones, and the characteristics of the knowledge contributors) were considered. To achieve the purpose of the research, a survey and statistical analysis were conducted. MasterCard, Visa, and PayPal were the most popular payment methods on desktops and mobile phones, respectively. The ease of use and security of these payment options may be the primary reasons why our participants choose them.
- *Users' Evaluation of a New Web Browser Payment Interface for Facilitating the Use of Multiple Payment Systems*. This publication focuses on the need for solutions designed to respond to user intention in (M)EPS. A new web browser payment interface is proposed, which considers user preferences to support multiple payment systems and permits user to specify what requirements must be met. Consequently, due to its improved evaluation over the Chrome web browser's payment interface, the new payment interface may accommodate a variety of payment systems, make it easier for users to choose their preferred payment method, and raise service acceptance. In addition, the suggested solution is reviewed in a survey and a new design for the proposed web payment interface is presented. Security is the largest

significant coefficient connected with user perceptions of interface payment methods, followed by ease of use and usefulness.

- *Research in Electronic and Mobile Payment Systems: A Bibliometric Analysis*. This publication is to highlight the prevalent research gaps in (M)EPS and to provide academics with the resources to investigate newly revealed research concerns. To fill this gap, a bibliometric analysis was conducted. In addition, this strategy is implemented and evaluated utilizing a topic search syntax based on the analysis of the following keywords: electronic payment system, mobile payment system, e-payment, m-payment, payment framework, payment interface, preference, acceptance, satisfaction, and technology acceptance model (TAM). According to the obtained results, the study serves as a framework for future research, and this bibliometric analysis proves the importance of our research topic.

The bibliography for this thesis is incorporated in Chapter 5, and it includes the publications stated in Section 5.1 as well as other additional publications generated during the development of this thesis (Section 5.2).

Chapter 3

Introduction

In recent years, developments in communication technology have enabled the establishment of electronic transactions for the purchase of products and services online at any time. In this sense, the diversity of authorized payment methods has aided in the development of the online payment field. With new payment methods and functionalities, (Mobile) electronic payment systems ((M)EPS) are increasing and continually developing today [22,61]. Up to this point, research has mostly focused on its acceptance and intent to use. Secondly, because it is a powerful theory for predicting user acceptance of technology, many academics have attempted to adapt a model to match varied circumstances [23,24]. Indeed, empirical testing have demonstrated that TAM is a reliable model for information technology [25,26].

This variety of electronic payment solutions, particularly mobile payment systems, generates interoperability, usability, and security issues [4, 13,60]. For this reason, the W3C established the Online Payments Interest Group (WPIG) to address these concerns and promote competition and innovation in online payments [27,28]. Additionally, given the present remarkable growth of e-commerce, businesses and merchants may be required to provide multiple payment procedures so that users can choose the most convenient for them and make the payment. Electronic payment frameworks were created to achieve facilitating the choice of the payment system and perform payment transactions [9]. However, so far, payment frameworks were not defined to be included in the web browser facilitating the capture of payment information and, then, launching the (automatic) choice of payment system and the subsequent payment.

To accomplish this, it is necessary to address at least the following issues: working to develop a universal payment interface, evolving and deploying a wallet, as well as issues with interoperability, security, trust, and confidentiality. Once these issues have been resolved, various payment protocols can be negotiated and put into place, and payment information can be automatically situated and processed.

To cope with these issues related to (M)EPS and payment frameworks, on the one hand, this thesis identifies payment system characteristics in order to comprehend the challenges and potential of (M)EPS and, on the other hand, it proposes a new payment interface solution that may support multiple payment systems, assist clients in selecting their preferred payment method, and increase service acceptance. This payment interface aims at improving the one already incorporated in current web browsers that are supporting W3C payment API. These contributions will be explained throughout this chapter.

The rest of this chapter is organized as follows. We analyze the (M)EPS and its characteristics in Section 3.1, and Section 3.2 describes payment frameworks and their purposes in regard to the W3C proposal. The user's acceptance is shown in Section 3.3. Section 3.4 presents related work. Then, in Section 3.5, we illustrate our proposed new payment interface for facilitating the use of numerous payment systems, as well as its advantages. Finally, Section 3.6 describes the challenge we face and how this thesis contributed to it, emphasizing the outcomes attained and the difficulties that may be encountered in the future.

3.1 (Mobile) Electronic Payment systems

E-commerce has altered how people do business. The electronic payment system is one of the most important components of e-commerce and is considered as its backbone. Electronic and mobile payment systems are becoming increasingly popular as research topics. Numerous of electronic payment systems (EPS), mobile payment systems (MPS) [13, 29,61], and payment frameworks (PF) [9, 30] have been established to facilitate making payments via the Internet in diverse manners. Then, the World Wide Web Consortium (W3C), through its Web Payment Working Group [6,8,30,31], is attempting to create and develop software and APIs to make different payment methods available on the Web in an easy and secure way [4,5,11,12].

A (mobile) electronic payment system – (M)EPS - is a collection of instruments and procedures for accepting payments between users, merchants, and banks. Consequently, a (M)EPS is required to facilitate effective payment and settlement procedures. Additionally, (M)EPS includes new functionality that was created to enhance certain service offerings and better meet user requirements and acceptance [32]. Therefore, (M)EPS must conform to an effective security standard that ensures high security for online transactions in order to be

widely recognized as a payment method globally. The hardest element of the payment process is establishing trust and security.

A (M)EPS so that it is accepted and be useful should satisfy certain ideal requirements. The most significant fundamental requirements for Internet-based (M)EPS are as follows:

Ease of use. Despite the critical requirement to replace the traditional money with electronic commerce, a new payment method must preserve the ease of use of cash currency [12].

Usefulness. Perceived usefulness is defined as "the prospective consumer's subjective belief that utilizing a given system will increase his or her job performance in an organizational context" [16]. As a consequence, users will employ m-payment systems if they discover a solution that meets their transactional or financial needs.

Non-Repudiation. is an element required for every payment system with the recognized payment, and production receipts. This payment proof can prevent changes to or destruction of transaction information during transmission [33]. EPS must be built such that consumers and businesses cannot deny their participation in a transaction if they were engaged.

Security. Because the major challenge of e-commerce is the dematerialization of customers' cash, the objective of security is the most important performance requirement of a payment method. Tsiakis and Sthephanides [34] defined security as a set of procedures and computer programs to authenticate the integrity and privacy of the information.

Privacy. Concerning the user's identity and sources of the person's income must not be revealed to external parties without her permission [33]. Martnez-Peláez and J. Rico-Novella (2010) [35] define privacy as a prerequisite for security in mobile payment protocols, in order to provide a higher security when sending financial data over wireless networks.

Anonymity. It guarantees that the merchant will not be able to know the client's bank account or personal information [11].

Integrity. This eliminates any involved party or adversary from modifying transaction information without being noticed [36].

Trust. Trust is the degree of assurance that the transaction payment and private details will be entirely safe and that the interested parties will not act against the user's best interests [37].

Confidentiality. Is the protection of private information from both inadvertent and purposeful attacks[36]. We can use any symmetric encryption scheme to achieve content confidentiality.

Scalability. The payment platform should be able to accommodate the increase in customers and merchants without degrading performance [38].

Interoperability. refers to the degree of integration between the system and the system's back end [39].

Flexibility. A payment method's flexibility necessitates independence from a specific support system. This feature allow user to conduct transactions from the location of his/her choice.

Compatibility. gets the coherence between an innovation and values, experiences and needs of adopting potential [40]. The compatibility was found as a significant determiner of the mobile technology and the adoption of services [41].

Convenience. is defined as the consistency of advancement with consumer experiences, values, and needs. It has also been cited as a key aspect in the success of mobile commerce [42].

Universality. The payment method's universality stems from the fact that it may be used not just in the context of electronic commerce through the Internet, but also outside of this Information Technology infrastructure, such as for ordinary purchases that previously needed cash or another form of credit. Universality necessitates the adaptation of methodologies to worldwide relations [43].

Cost. The effective cost of a transaction is one of the main variables influencing customer adoption of mobile payment systems [44]. To the greatest degree possible, m-payments should not be more expensive than conventional payment mechanisms [45].

Authentication is the process of verifying a person's identity. Martnez-Peláez and J. Rico-Novella (2010) [35], describe authentication as a component of the security requirement in mobile payment systems.

Reliability. E-payments must be available online 24 hours a day, which implies the EPS operation system must not fail at any moment [35].

Convertibility. It provides an electronic payment system that permits the conversion of digital currency into real currency, which increases the value of the system for end users by making it more easily accessible and accepted [35].

Mobility. This feature, which is the most important for an MPS, means that the system is available at any time and from any place, with the ability to access services ubiquitously [42].

Authorization. For a transaction and a payment to be legitimate, the authority requirement must be met. This is one of the most critical factors to consider [11].

In the same way that we have just presented (M)EPS and their properties, a number of studies have been carried out to accurately determine user acceptance, as well as several

payment frameworks have been defined to facilitate the use and support several payment systems [5] in order to ensure the security, confidentiality, and availability of the (M)EPS.

Next section defines payment frameworks and their goals for supporting the selection of the payment system used to perform an online payment in an e-commerce transaction, as well as to review the state of the art on user selection of electronic payment (mobile) for a purchase transaction.

3.2 Payment frameworks

In general, consumers supported many electronic payment systems. Numerous payment frameworks were created with the goal of providing a broad range of choices in order to enable the choice of an electronic payment system and the subsequent execution of the payment process for this scenario where customers may pay via multiple (M)EPS.

Furthermore, from their external appearance, electronic payment systems might be determined to be either enhanced or still in need of improvement. Then, according to Ruiz-Martnez (2015) [30], the goal of an online payment framework is to define specific functionalities, to facilitate the purchase process and the communication of payment information, allowing diverse payment instruments to be utilized while ensuring interoperability, security, and trust.

Several studies [9, 12,13,30,61] have been conducted throughout the years to optimize the flow of online transactions and better gauge user approval. Several payment frameworks have been put in place to facilitate and support the use of several payment systems [9, 47], such as Secure electronic marketplace for Europe (SEMPER) [3], Internet Open Trading Protocol (IOTP) [3, 46], and Pay Frameworks [3]. Ruiz-Martínez et al., 2012 [5], provided a broad approach based on a set of generic components that aid in the implementation of payment frameworks for the purposes of negotiation and payment protocol choice. Additionally, payment frameworks are being improved and developed to enable, on the one hand, the purchase process and the interchange of payment information, and, on the other hand, the customization of services for the user, data protection, monitoring, and payment control.

The Web Payments Interest Group (WPIG) [6,7], taking into account the need of making easy and secure the use of electronic payment on the web, announced new project activities to understand the various functionalities of an online payment, to develop of a payment framework which is to be loaded in any web browser, and to analyze the consortium's future involvement in e-commerce related activities to address these

concerns and promote innovation in online payments [31,48].

3.3 User's acceptance in payment systems

Understanding electronic payment system acceptance is one of the most well-established areas of study within the field of payment systems [15,16,22,23]. The theories of acceptance and adoption described here explore at the mechanics of the payment method acceptance model. A number of models have been proposed to describe the effect of consumer expectations on technology adoption. Some of these include diffusion and innovation approach [22], theory of planned behavior [49], unified theory of acceptance and use of technology (UTAUT) [23], and Technology Acceptance Model (TAM) [12,15,50,51]. These approaches might be used to explain why some technologies, such as mobile payments, mobile banking, or electronic payment systems, have garnered considerable attention [51]. Turban et al. [12] used the Technology Acceptance Model (TAM) to illustrate why service providers should prioritize service quality. Davis [24] created a TAM to evaluate the acceptability of a new technology/invention.

Based on the TAM model, many studies have been carried out throughout the years to include new concepts in order to improve user acceptance and assure the security, confidentiality, and availability of the (M)EPS [34,36,52]. This model can also be used to demonstrate a particular aspect of service evaluation, such as loyalty and satisfaction of customers [11] or trust [34,37].

Furthermore, the user acceptance model, based on these, assures users what function of an electronic payment system is useful and accepted. Additionally, ease of use, usefulness, security, trust, privacy and confidentiality, anonymity, and non-repudiation are some of the favorable features to satisfy customer requirements [43,45,51,61].

3.4 Related work

The primary goal of this section is to examine relevant studies related to (M)EPS, payment frameworks, used for online shopping, and user satisfaction [13,53,60]. Research on electronic and mobile payment systems is expanding [9, 12,13,61]. Consumers employ different online payment methods, including credit cards, debit transactions, and mobile payment systems such as PayPal, Bitcoin, Samsung Pay, and Google Pay [54, 55]. However, the variety of payment alternatives supported by different business models necessitates the development of systems that address various concerns such as the finding of payment information associated with the product/service and the negotiation of the form of payment to

complete the transaction. The definition of electronic payment frameworks has been proposed to overcome these concerns. These frameworks attempt to simplify the sharing of payment information and the usage of various payment instruments throughout the purchase process while ensuring interoperability, trust, and security [31, 5]. Additionally, due to the rapid growth of e-commerce, the W3C established the Online Payments Interest Group (WPIG) to address these concerns, encourage competition and innovation in online payments [48], and help a large number of users in selecting the proper payment systems.

Likewise, with the growth of (M)EPS, customers need to select the best electronic payment systems that meets their preferences or requirements. To cope with this need, studies on acceptance and intention to use (M)EPS are required due to their relevance in the selection of payment systems [13,53,60]. Besides, acceptance studies made so far focused on electronic payment systems demonstrates that considerable impacts emerge from ease of use, perceived quality, and satisfaction depending on context, culture, and technology [18,56,61].

According to Putri et al., 2019 [47], consumers can use a hierarchical decision-making process to exclude options based on their availability or acceptability in the given scenario. If the consumer cannot find an acceptable method of payment, he/she may abandon the transaction. Further, Liébana-Cabanillas, F et al 2019 [53] show that the choice of a payment method was impacted mostly by convenience, acceptability, accessibility, or preferences. In this same research line, Deufel and Kemper, (2018) [54] investigated the impact of demographics and consumer behaviors on payment method choice and disc 3.4. Related word risk customer's perception influences how they select a payment method.

Otherwise, our research is useful since it includes the domains of (M)EPS, payment interface, TAM, payment framework, and user’s preferences, whereas past research has mostly focused on a single, narrow subject. Trütsch [57] identified the effect of m-payment on payment method choice and emphasized the differences between mobile and traditional payment systems. Established research, on the other hand, has mostly addressed m-payments acceptance [47] from a wide viewpoint, as well as the technology acceptance model (TAM) [45], and the unified theory of acceptance and use of technology (UTAUT) [58]. Furthermore, in order to have a better knowledge of the topic of m-payment, Abdullah and Mohammed Naved Khan [19] performed a thorough literature search and bibliometric analysis on a sample of 56 papers published in 44 established international journals. They discovered that the number of m-payment articles has increased since 2014, with the majority of authors originating in the United States.

For this understanding on (M)EPS, a literature review was carried out [60]. It was based

on a corpus of research that examines the features provided by (M)EPS. As a consequence, we discovered that nine features should be considered when designing (M)EPS. These include security, cost, confidence, privacy, authentication, confidentiality, integrity, non-repudiation, and anonymity. It appears to connect mobile payments, electronic payments, and customer-preferred payments.

In this regard, in this thesis, a research was done to investigate the factors that impact customers' decisions to make online payments. For this objective, four components were studied: demographic description, web browser choice, most preferred payment method, and knowledge contributor characteristics [61]. As a result, the study highlights user preferences when choosing a payment method to expedite the payment process, as well as the aspects users' value most throughout an online payment transaction.

On the other side, many e/m-commerce consumers would like to adopt a user-friendly payment interface for all online payment transactions, demonstrating that the need for a new intuitive payment interface is still relevant and necessary. Particular attention was paid to payment features, which included security, ease of use, privacy, usefulness, storage of information, automated selection of the best payment method, convenience, timeliness, accuracy, and transaction costs/fees. The new suggested payment interface may support several payment systems, aid customers in selecting their preferred payment method and increase service acceptance [62].

In addition, the suggested a payment interface makes a theoretical contribution by developing a model for gauging user satisfaction and readiness to adopt a new payment interface. Furthermore, to the best of our knowledge, no previous research has used this method to investigate electronic and mobile payment systems and examine the interaction between multiple payment systems, payment frameworks, acceptance, and payment functionality.

This research thesis' theoretical approach is focused on the act of defining the main concerns of the (M)EPS and payment frameworks from previous works in order to design a payment interface that achieves user acceptance objectives. Furthermore, the study conducted in this thesis is valuable in gaining an awareness of the present status of the characteristics offered by (M)EPS, which should be taken into account when developing new payment systems.

This study gives an early overview of electronic and mobile payment study in order to visualize their research's progress. A bibliometric analysis [63]. was carried out as part of a new study that employed this approach to identify common research gaps and to allow researchers to investigate new recognized research subjects. The bibliometric analysis

demonstrates the increasing significance of our study subject over time. In addition, current research on the subject has been thoroughly analyzed, and a significant rising tendency suggests future study prospects in this field. Meanwhile, this work will serve as the foundation for future research.

3.5 A New Web Payment Interface for facilitating the use of multiple payment systems

The major objective of this thesis was to create a payment interface to assist payments when the user supports multiple payment systems taking into account user preferences and features that they appreciate the most to make the payment process easier. To achieve this goal, the previous section states that one of the most important issues in this context is to use a payment interface that supports multiple payment systems and support the choice of the user's preferred payment solution independently of the device used. In this case, the proposal made by W3C through the Web Payment API was chosen since it aims to offer a standardized solution to make payment on the Web (W3C, 2015) [6]. This API is being developed and implemented by the main web browsers. During this research, we examined Google Chrome's web payment interface and decided to improve registration/authorization and exceed of payment management based on lessons learned from researching (M)EPS functionality and user preferences to facilitate payment selection and processing when the user supports multiple payment systems. Thus, this work contributes to the existing research on this problem by conceptually studying which elements influence the design of a payment interface, which is based on the concept of an API implementable on web browsers and responds to user preferences and allows different payment methods, and by reviewing the payment interface of the Google Chrome web browser (GCWB) (Fig. 1). Therefore, when a user connects into Chrome and visits the present GCWB payment interface, they may fill out payment forms with payment methods already saved in their Google account. To pay for online purchases with a credit card associated to a Google account, user must input a security code. Every time the browser is started, Chrome checks that the user has a specified action to complete. That is why its designers are always thinking of new features that will enhance the user experience.

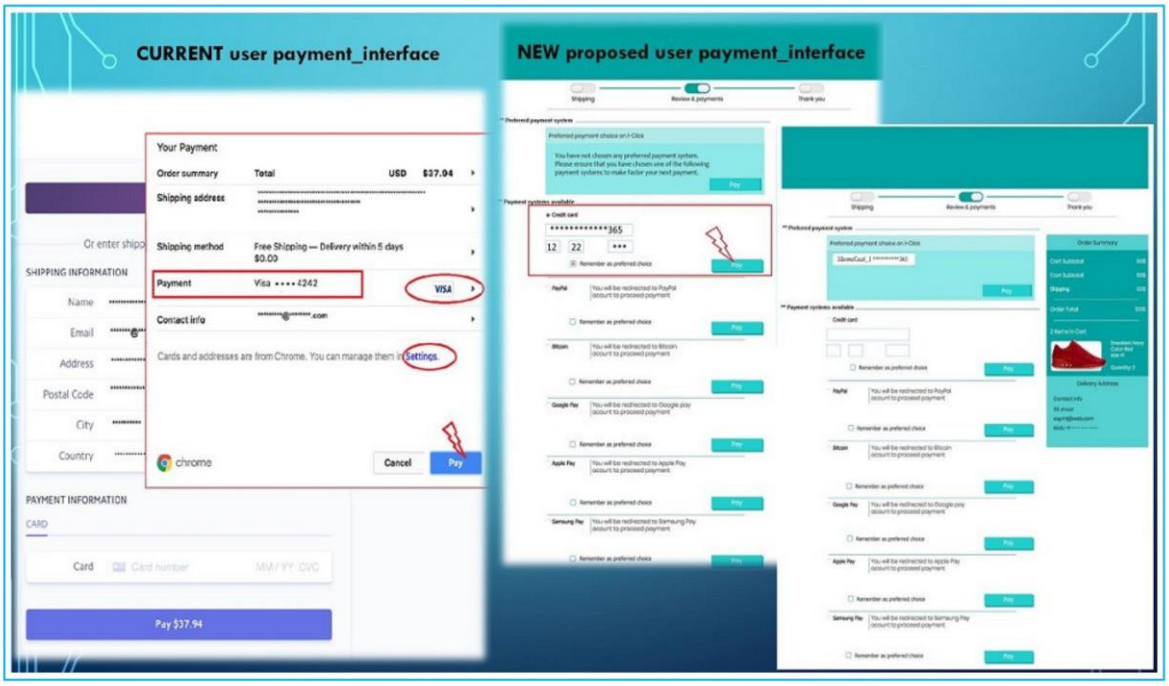

Figure 1. Screenshot of GCWB interface and the new proposed payment interface.

Based on an examination of payment literature [59] and the GCWB payment interface, as well as the extension of the technological acceptance model (TAM), a user acceptance survey (266 participants) was conducted to understand the various payment methods that should be included and user preferences to facilitate the payment process. The relevant questions in the survey presented various payment system solutions (Credit Card, PayPal, Bitcoin, Google Pay, Apple Pay, and Samsung Pay) and asked respondents to indicate which solutions they prefer and use the most, as well as the most important factors (ease of use, usefulness, security, confidentiality, privacy, payment method preferences, visual interface design, credibility, and desirability) when choosing their payment method. These questions were used to determine which payment methods may be featured in the interface. Following that, we used multiple-choice questions to compare the present payment interface (GCWB) with the proposed payment interface (Fig.1). Finally, for data analysis, a linear regression analysis with the crosstab approach revealed the correlations between the various functionalities, factors, and chosen payment method. These findings are consistent with prior research on accepting (M)EPS [13,53,60] to easily define the payment interface that responds to user acceptance.

In the sequence diagram shown in Figure 2, it is illustrated how objects and components (browsers, interface payment solution, and merchant) interact to complete a payment process. It enables browsers, payment interfaces, merchants, and customers to have several flowlines to

indicate the chronology for the events and transformations on each of the flows required to perform the system's functions.

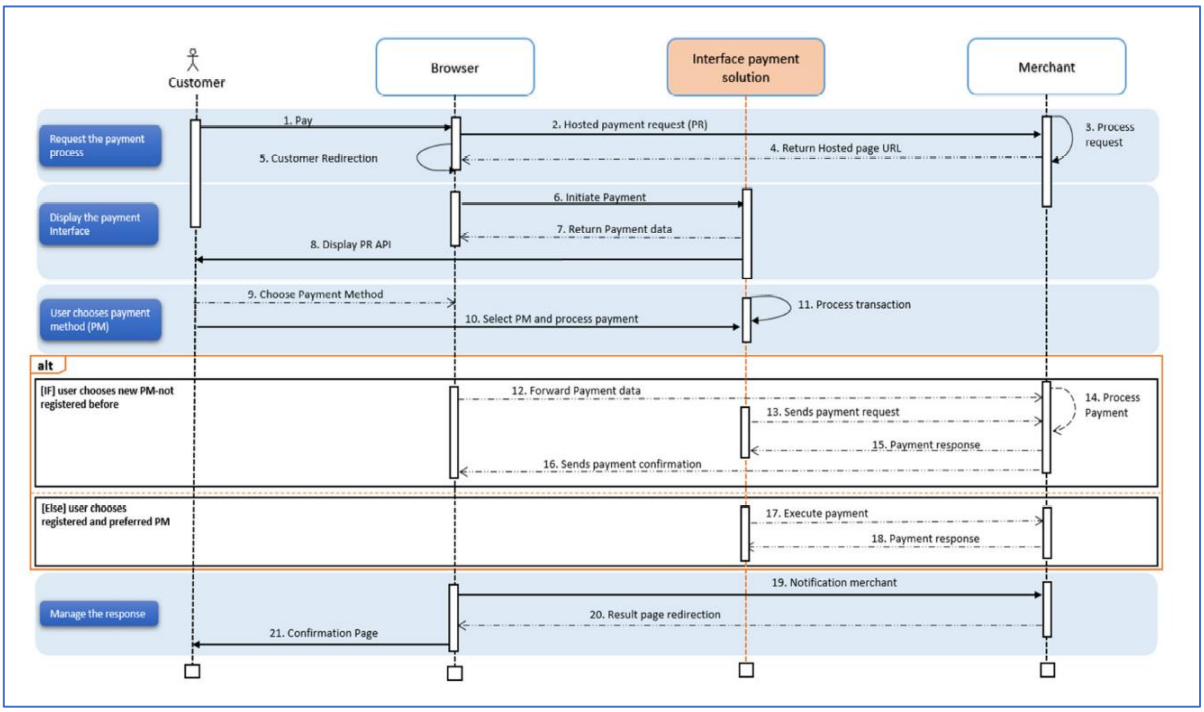

Figure 2. Sequence diagram schema.

In our diagram, an alternate combined fragment is utilized to describe a collection of lifelines/actors to demonstrate conditional flow. In this flow, user is connected to the payment interface via electronic (mobile) terminals. The appropriate product information is then displayed to user when he/she has selected his/her items and added them to their shopping cart. Using our suggested payment interface is required for users to authenticate their online shopping carts. The mockup for the web payment interface was created using the graphics editor platform Adobe Photoshop CS6 2020. Figures 1 and 3 show how the interface is split into two items:

- **Items-1: Preferred payment system [One-Click payment]**

  This component demonstrates the new functionality, usability, usefulness, and security. User may pick one of the previously registered preferred payment methods and verify and complete the purchasing with a single click.

- **Items-2: A payment method is provided.**

  This section describes the many payment options that are supported by this solution. To authenticate their payment procedure, user may choose a payment method ("Options" button) from the list of preset payment options.

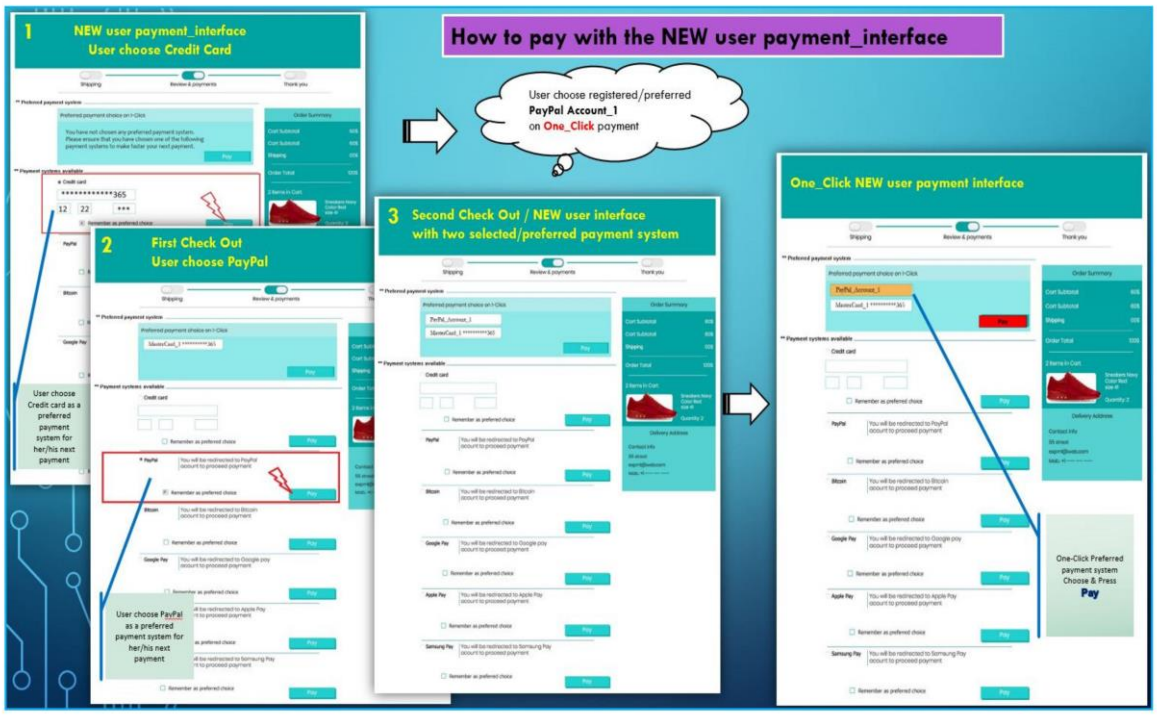

Figure 3. Screenshot detailing the payment process using the new proposed payment interface.

According to the findings, users are satisfied with the new payment interface, and they appreciate more payment choices than the previous GCWB interface. The most important factors in embracing a new payment interface are ease of use, usefulness, security, confidentiality, privacy, payment method preferences, visual interface design, and credibility. Likewise, this research was able to enhance the limited factual research and study on (M)EPS in the context of customer acceptance, and it may be of interest to the W3C payment group.

3.6 Lessons learned, conclusions and future work

User acceptance of a new payment interface is prone to change due to the growth of numerous payment systems and frameworks over time, and the complexity of the payment interface design process, which must take into consideration payment system comprehension and user acceptance. In this direction, the incorporation of a new web payment interface in browsers allows the development of innovative online payment services aimed at improving people's life quality by responding to user preferences. However, achieving this goal remains challenging due to increased security, trust, and privacy concerns about the treatment of the information transferred. This is especially important in the case of sensitive information, such

as personal data, because inappropriate use of this information might possibly pose a risk. Furthermore, in order to secure data protection during the payment process, security measures must be taken into account.

This thesis shows that among the top hot study subjects currently attracting increased interest from academics are security, ease of use, usefulness, trust, and privacy in the context of online payment. The positive results of our study enable us to share them with the W3C Payments and Web Standardization Group in order to further improve the field of online payments, assuming that people proceed using (M)EPS more than before, and that the problems and demographic preferences may change as a result of increased use of (M)EPS.

The limits of our research prompt us to suggest many potential directions for future study: Future studies might be built on this investigation by gathering and contrasting user attitudes on mobile payment platforms with various interface components and functions. Further, it is essential to investigate how perceived interface design elements affect perceived security in different mobile payment platforms. Also, our proposal was examined as a mock-up, and it would be interesting to create a functional prototype that could be used and evaluated by several users to provide a more accurate evaluation of the parts that need to be improved. Therefore, additional study on the number of payment systems that are used would be fascinating, with an emphasis on electronic (mobile) payment systems, payment frameworks, and payment interfaces.

Finally, we propose expanding our research to investigate the development of a functional API (W3C) that meets user preferences and supports multiple payment method, as well as the establishment of more efficient and timely strategies to manage appropriate e-commerce and online payment policies (e/m-payment).

Chapter 4

Publications composing the PhD Thesis

4.1 Users Supporting Multiple (Mobile) Electronic Payment Systems in Online Purchases: An Empirical Study of Their Payment Transaction Preferences

Title	**Users Supporting Multiple (Mobile) Electronic Payment Systems in Online Purchases: An Empirical Study of Their Payment Transaction Preferences**
Authors	Oussama Tounekti, Antonio Ruiz-Martínez, and Antonio F. Skarmeta-Gómez
Type	Journal
Journal	IEEE Access
Impact factor (2020)	3.476
Rank	Q1
Publisher	IEEE
Volume	8
Pages	735-766
Year	2019
Month	December
DOI	10.1109/ACCESS.2019.2961785
URL	https://ieeexplore.ieee.org/document/8939372
State	Published

ABSTRACT

The online payment for products or for the access to payment-based services can be made by means of a range of (mobile) electronic payment systems (M)EPS. Both the industrial sector and research community, mainly World Wide Web Consortium (W3C), are working on facilitating these payment methods on Web and supporting the multiple users on how they can select the suitable (M)EPS. However, to the best of our knowledge, there were no thorough studies considering consumer's preferences when they support multiple (M)EPS. To address this issue, we have performed a survey on an international participants(n=272) aiming to (i) developed a theoretical model to determine their preferences when they are supporting more than one (M)EPS, (ii) nd the most valuable option according to them and (iii) determine the surrounding conditions that support their decision to use a specic (M)EPS. The theoretical framework of this study was based on the Technology Acceptance Model (TAM). According to our statistical analysis (Chi-square test), consumers that can pay using different (M)EPS during their online payment transaction, have a preferred payment system based on its security, fees, usefulness, and ease of use as well as on their favorite Web browser for these transactions. Factor analysis was also performed to identify factors that much influence the (M)EPS. Results revealed that the factors influencing online payment preferences differ from those involved in traditional payment methods. Our findings allowed, therefore, providing practical suggestions for supporting payment processes with Web browsers and the W3C payment Application Program Interface (API).

4.2 Users' Evaluation of a New Web Browser Payment Interface for Facilitating the Use of Multiple Payment Systems

Title	**Users' Evaluation of a New Web Browser Payment Interface for Facilitating the Use of Multiple Payment Systems**
Authors	Oussama Tounekti, Antonio Ruiz-Martínez, and Antonio F. Skarmeta-Gómez
Type	Journal
Journal	Sustainability
Impact factor (2022)	3.889
Rank	Q1
Publisher	Multidisciplinary Digital Publishing Institute
Volume	13
Pages	4711
Year	2021
Month	April
DOI	10.3390/su13094711
URL	https://www.mdpi.com/2071-1050/13/9/4711
State	Published

Abstract
The availability of multiple (mobile) electronic payment systems ((M)EPS) has led to the development of web browser payment interfaces that support various payment systems, facilitate the transaction, the choice of the payment system, and perform the payment. However, so far, no in-depth study on user satisfaction determinants with these interfaces has been conducted. Our work aims to cope with this issue. Thus, based on the analysis of payment literature and Google Chrome web browser (GCWB) payment interface, we propose a new web browser payment interface that considers users' preferences to support multiple payment systems. Furthermore, we have developed a theoretical model to determine users' preferences to support multiple payment systems. Our model is based on the extension of technology acceptance models. Finally, we evaluated both the theoretical and proposed payment interface through a survey research approach (n = 266); data were collected, and the hypotheses were tested via statistical analysis (chi-square test, regression coefficients). Our experimental results revealed that our proposed interface is accepted, easy to use, and satisfies users' needs. The key factors for accepting a new web browser payment interface are ease of use, usefulness, security, confidentiality, privacy, payment method preferences, visual interface design, and credibility.

4.3 Research in Electronic and Mobile Payment Systems: A Bibliometric Analysis

Title	**Research in Electronic and Mobile Payment Systems: A Bibliometric Analysis**
Authors	Oussama Tounekti, Antonio Ruiz-Martínez, and Antonio F. Skarmeta-Gómez
Type	Journal
Journal	Sustainability
Impact factor (2022)	3.889
Rank	Q1
Publisher	Multidisciplinary Digital Publishing Institute
Volume	14
Pages	7661
Year	2022
Month	June
DOI	10.3390/su14137661
URL	https://www.mdpi.com/2071-1050/14/13/7661
State	Published

Abstract

Electronic (mobile) payment systems are an important aspect of e-commerce. However, few reviews highlight the most significant findings and challenges. In this article, we have prepared a bibliometric analysis to provide a statistical overview of previously published research papers on electronic (mobile) payment systems and user preferences, with a particular emphasis on their diverse techniques and analyses, as well as comprehensive and reliable directions to reveal evolutionary nuances and highlighting emerging areas in this specific research. This study reviewed 177 scientific papers published between 2001 and November 2021 in the Web of Science (WoS) database on the subjects of electronic payment systems (EPS) and mobile payment systems (MPS), payment interface (PI), technology acceptance model (TAM), payment frameworks (PF), and user preferences (UP). The amount of studies using the abovementioned topics (EPS, MPS, TAM, PF, and UP) increases annually. Spain, China, and Malaysia are the three main countries that actively participate, and their international academic partnership is relatively close. We have compiled a list of the most relevant publications, prolific authors, institutions, and leading research topics. The articles were used to evaluate bibliometric indicators, analyze research activity, investigate the subject's evolution, and identify the most interconnected themes. The findings provide a comprehensive overview of existing thematic studies, with a notable rising trend showing the potential for future research in the field. The study provides a guideline for further research.

Chapter 5

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