Inbound, Outbound and Coupled Open Innovation and Innovation Performance: Evidence from Renault's Business Ecosystem in Tangier, Morocco

L'innovation ouverte *inbound*, *outbound* et couplée et la performance d'innovation : le cas de l'écosystème d'affaires de Renault à Tanger, Maroc

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ABSTRACT. After a long era of closed innovation, firms have opened their innovation processes to external ideas and organized themselves into business ecosystems, in which diverse actors develop their capabilities and simultaneously cooperate and compete around a shared goal: innovation. Prior research links open innovation practices to innovation performance, as collaboration with diverse partners brings additional ideas, knowledge, skills and technologies. Yet this relationship remains scarcely examined in the automotive business ecosystems of emerging economies. As Morocco has become North Africa's leading automotive producer, eight business ecosystems have emerged in the country, the leading one being that of Renault, which has reshaped Morocco's industrial landscape and unlocked new potential for its automotive industry. This paper analyzes how inbound, outbound and coupled open innovation affect the innovation performance of firms operating within Renault's business ecosystem in Morocco. A quantitative approach was adopted: a seven-point Likert-scale questionnaire was administered from 1 June 2023 to 31 January 2024 to ecosystem actors, including employees, suppliers, automotive manufacturers, competitors, customers and the Training Institutes for Automotive Industry Professions. The 196 usable responses were analyzed through principal component analysis, reliability tests and multiple regression. The three dimensions of open innovation each have a significant positive effect on innovation performance, jointly explaining 54.9% of its variance. Inbound open innovation has the strongest effect, followed by outbound and coupled open innovation. Thus, although the Renault-Nissan-Mitsubishi Alliance makes coupled practices central to the ecosystem, absorbing external knowledge remains the main driver of innovation performance in business ecosystems specialized in automotive manufacturing. These findings help ecosystem managers and policymakers prioritize the knowledge flows that most strengthen local innovation capabilities.

RÉSUMÉ. Après une longue ère d'innovation fermée, les entreprises ont ouvert leurs processus d'innovation aux idées externes et se sont organisées en écosystèmes d'affaires, au sein desquels des acteurs diversifiés développent leurs capacités, coopèrent et se concurrencent simultanément autour d'un objectif commun : l'innovation. La littérature associe les pratiques d'innovation ouverte à la performance d'innovation, la collaboration avec des partenaires variés apportant des idées, des connaissances, des compétences et des technologies supplémentaires. Cette relation reste pourtant peu étudiée dans les écosystèmes d'affaires automobiles des économies émergentes. Alors que le Maroc est devenu le premier producteur automobile d'Afrique du Nord, huit écosystèmes d'affaires ont émergé dans le pays, le principal étant celui de Renault, qui a remodelé le paysage industriel marocain et ouvert de nouvelles perspectives à son industrie automobile. Cet article analyse l'effet de l'innovation ouverte *inbound*, *outbound* et couplée sur la performance d'innovation des entreprises évoluant au sein de l'écosystème d'affaires de Renault au Maroc. Une approche quantitative a été adoptée : un questionnaire fondé sur des échelles de Likert à sept points a été administré du 1er juin 2023 au 31 janvier 2024 aux acteurs de l'écosystème, notamment des employés, des fournisseurs, des constructeurs automobiles, des concurrents, des clients et les Instituts de Formation aux Métiers de l'Industrie Automobile. Les 196 réponses exploitables ont été analysées au moyen d'une analyse en composantes principales, de tests de fiabilité et d'une régression multiple. Les trois dimensions de l'innovation ouverte exercent chacune un effet positif et significatif sur la performance d'innovation et en expliquent conjointement 54,9 % de la variance. L'innovation ouverte *inbound* a l'effet le plus fort, suivie de l'innovation *outbound* puis de l'innovation couplée. Ainsi, bien que l'Alliance Renault-Nissan-Mitsubishi place les pratiques couplées au cœur de l'écosystème, l'absorption de connaissances externes demeure le principal levier de la performance d'innovation dans les écosystèmes d'affaires spécialisés dans la construction automobile. Ces

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résultats aident les gestionnaires d'écosystèmes et les décideurs publics à prioriser les flux de connaissances qui renforcent le plus les capacités d'innovation locales.
KEYWORDS. Inbound open innovation, Outbound open innovation, Coupled open innovation, Innovation performance, Business ecosystems.
MOTS-CLÉS. Innovation ouverte *inbound*, Innovation ouverte *outbound*, Innovation ouverte couplée, Performance d'innovation, Écosystèmes d'affaires.

1. Introduction

Competition, risk and uncertainty limit firms' capacity to drive R&D and capture critical knowledge alone [FER 23, WAN 24], making independent, self-contained innovation increasingly untenable [CHE 06a]. This shift gave rise to a new paradigm in business strategy and innovation practice [WAN 24], where open innovation ecosystems operate as coordinated architectures of complex collaboration, leveraging cross-firm knowledge and fostering spillovers [JAC 24].

Beyond semiconductors, ICT and pharmaceuticals [CHE 06b], open innovation research has mainly focused on large multinationals [CHE 06a] and has scarcely examined other industries, such as the automotive industry [DEM 12]. The automotive industry is highly innovative, spanning the full supply chain — R&D, machinery, ICT, electronics, design, engineering, sales and energy [STU 08]. Rising costs and complexity increasingly pressure carmakers to integrate innovations from beyond firm boundaries [LAU 06]. Notable examples include Tesla Motors' strategic alliances with providers (Lotus UK, Panasonic Japan), R&D partners (Dana Holding Corp.), OEM partners (Freightliner, Toyota) and government loan support [KARA 13]. Emerging automotive economies increasingly rely on similar open innovation dynamics to catch up technologically and integrate global value chains [HAH 17]. Morocco illustrates this trend: its automotive industry sits at the core of national industrial development [HAH 17], centered on assembly and led by Renault and Stellantis alongside their national and international suppliers. As the keystone, Renault runs its own "builder ecosystem" around supply development, innovation and coordinated competencies [SEB 22] — a configuration comparable to automotive clusters emerging in other developing economies. This raises the research question: how does open innovation shape innovation performance within an automotive business ecosystem in an emerging economy, illustrated by the case of Renault in Morocco?

Most research has studied open innovation implementation qualitatively in low- and medium-technology firms [CHE 06b, SPI 11], while research on large companies has focused on inbound and outbound open innovation, largely within developed-economy contexts. This paper addresses that gap by studying open innovation within Morocco's Renault-led automotive business ecosystem as an illustrative case of emerging-economy automotive clusters, analyzing its impact on firms' innovation performance through a quantitative, Likert-scale survey of inbound, outbound and coupled open innovation practices. Beyond this specific context, the study contributes a transferable understanding of how the three dimensions of open innovation jointly condition innovation performance within manufacturing-based business ecosystems in emerging economies.

To address this research question, the study is structured as follows. Firstly, we develop the conceptual framework and the hypotheses. Drawing jointly on the literature on business ecosystems, open innovation and innovation performance, we examine how inbound, outbound and coupled open innovation activities unfold within business ecosystems and how they contribute to innovation performance, leading to three research hypotheses. Secondly, we present the quantitative research methodology. After introducing the empirical setting, Renault's automotive business ecosystem in Morocco, we describe the sampling procedure, the data collection process and the choice of measurement scales for each variable, before assessing the validity and reliability of the measures. Thirdly, we test the hypotheses linking inbound, outbound and coupled open innovation to innovation performance using multiple regression analysis. Finally, we discuss the main results in light of the literature and of the specific features of Renault's automotive business ecosystem, and conclude with the study's theoretical and managerial contributions, its limitations and avenues for future research.

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2. Literature review and hypotheses development

2.1. *Business ecosystems: a landscape for open innovation*

Over the last two decades, business ecosystems have attracted growing attention in both academic research and managerial practice [ADN 17]. A business ecosystem brings together a porous set of actors of different forms and natures, "with fluctuating degrees of multilateral, nongeneric complementarities that are not fully hierarchically controlled" [JAC 18, p. 2264]. These actors are organized within a modular structure of interdependent and interconnected networks that span several industries [IAN 04a]. They are led by a keystone actor, also referred to as the leader or focal firm, which shapes their coevolution together with the wider community of ecosystem members [IAN 04b, OH 16, THO 22]. As the central actors of the ecosystem, keystones promote a shared vision, align resources and orchestrate mutually beneficial activities for the members of their community [MOO 96].

Borrowed from ecology, the concept of business ecosystem emphasizes the strong interdependence and interconnectedness of a network of upstream and downstream actors. These include keystones, customers, complementors, suppliers, buyers, public authorities, regulators, the media and venture capitalists [BOM 17, DEV 18, DIN 17, GUE 16, MOO 96, WIT 18]. These actors coevolve through relationships that are simultaneously cooperative and competitive, a combination known as coopetition, in order to innovate continuously and ensure their survival. Extending the ecological analogy, the business ecosystem perspective transposes the dynamics observed between species to economic relationships among firms, moving beyond dyadic exchanges to foster technological collaboration and innovation [FAS 18, JAC 11].

Innovation lies at the heart of the business ecosystem [MOO 93]: its members compete and cooperate to deliver valuable new products, create value and satisfy customer needs [ADN 10, DIN 17]. Innovation thus emerges from the interdependencies between participants, from knowledge flows and from collaboration [ARE 20, FRA 18]. Building on this view, scholars introduced the concept of innovation ecosystems to capture innovation processes that extend beyond the boundaries of a single industry or country [ADN 06, BRU 13, FAS 18, IAN 04c, MOO 93]. Organized as purposive communities, innovation ecosystems reflect "interlocking dynamics of collaboration, co-creation of value, trust and symbiotic complementary technologies and skills" [GOB 14, p. 55]. Open innovation ecosystems, in particular, involve an enlarged set of stakeholders characterized by a propensity for openness, coopetitive ties, joint value creation and complex value propositions [ADN 13a, CHES 14b, KAP 13, NAM 13, SCO 17, WES 08]. Within these ecosystems, a technology platform structures the collective assets, interfaces and standards [AUT 14, DAT 18, GAW 14], around which cooperative arrangements deliver "customer-facing solutions" [ADN 06, p. 98].

Business ecosystems therefore provide a natural setting for open innovation. The knowledge flows that circulate between the keystone, its suppliers, complementors, customers and partner institutions are precisely the inbound, outbound and coupled flows on which open innovation relies. Moreover, because the structure of the ecosystem shapes the ability of each member to create and capture value from innovation [ADN 10], the way these flows are managed is likely to influence innovation performance both at the level of individual firms and at the level of the ecosystem as a whole. This perspective is particularly relevant to the automotive industry, where carmakers act as keystones coordinating extensive networks of suppliers and partners. In Morocco, Renault plays this keystone role and anchors an automotive business ecosystem that also benefits from the strategic Renault-Nissan-Mitsubishi Alliance. This ecosystem constitutes the empirical setting of the present study.

2.2. *Open innovation, a three-dimensional typology*

The term open innovation was first coined by Chesbrough [CHE 03a] as a new path that moves beyond the closed innovation mindset and its traditional, inwardly focused industrial R&D, and it has since attracted considerable attention from academics and managers [CHES 14c]. It is most commonly

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defined as “the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively” [CHE 06a, p. 1]. By enhancing innovation and generating new income streams, open innovation encourages purposeful interactions with exogenous entities [BOG 17, CHES 14c, REM 23]. Following its emergence, the concept gained considerable salience [CHE 06c], and open practices have attracted burgeoning interest as companies increasingly operate through open innovation activities [VAN 14]. More recently, the literature has extended open innovation to innovation ecosystems, stressing the synergies between large companies and the greater innovation resilience they generate [OLI 25].

The open innovation paradigm treats R&D processes as open systems [CHE 06a] and can be analyzed from the individual level through to public institutions. At the inter-organizational level, industry platforms such as alliances, networks and ecosystems orchestrate open innovation [VAN 12], broadening participation in innovation ecosystems [WES 14a] and enabling the cross-level knowledge flows that are essential to value creation [BOG 17]. At the intra-organizational level, employees drive these strategies by dedicating time to internal and external innovation [DAH 16] and by working with managers to realize the potential of open innovation [BOG 17]. Across these levels, open innovation takes different forms depending on the direction of the knowledge flows involved.

Open innovation is thus studied through three core processes: inbound, outbound and coupled [CHES 14c, GAS 04, RAD 19]. Inbound (outside-in) open innovation integrates external knowledge to boost internal innovation. It is the most studied form [CHES 14c, WES 14a] and operates through sourcing or acquisition [DAH 10, FLO 19]. Customers and suppliers are key inbound actors [LAU 06]: customer needs shape idea development and commercialization [PAR 12], while suppliers ensure flexible access to materials and technologies [INA 11]. Technology scouting identifies opportunities that guide product development decisions [PAR 12], and acquisition practices rely on partnerships with research centers and universities [DAH 10, VAN 11]. These practices serve different types of innovation: collaborative linkages with customers and universities mainly support product innovation, while openness towards rivals, suppliers and universities mainly supports process innovation [INA 11]. Inbound practices are particularly salient in the automotive industry, where carmakers must integrate knowledge from disciplines as diverse as chemistry for batteries, materials engineering and ICT for infotainment systems [COR 06, KAM 12], and increasingly draw on engineering firms, service suppliers, research associations, innovation consortia and even rivals [WIL 18].

Outbound (inside-out) open innovation manages knowledge outflows, allowing other organizations to benefit from unused assets [CHES 14c] through non-pecuniary revealing or pecuniary selling [DAH 10, FLO 19]. Revealing shares assets in exchange for indirect gains [DAH 10, HEN 14], whereas selling commercializes technological resources through out-licensing or corporate venturing [FLO 19, VAN 09], enabling better-positioned actors to bring innovations to market faster [DAH 10, WAL 12]. Corporate venturing creates and finances new ventures to enhance strategic value [NAP 11], often resulting in spin-offs and spin-outs [VAN 09]. In the automotive industry, outbound practices allow carmakers to commercialize unused innovations through better-suited organizations [DEM 12, KARL 13, SPI 11].

Coupled open innovation combines inbound and outbound flows within collaborative partnerships to develop and launch innovations [GAS 04]. It brings together complementary participants according to firms’ needs [CHES 14c] through alliances, platforms, co-patents and joint ventures [KAT 02]. Non-pecuniary coupled practices involve longitudinal knowledge sharing that reduces time and costs [VAN 09], while pecuniary practices are channeled through active sharing facilities [FLO 19], enabling participants to join innovation platforms and build new ties across society, academia and industry [YST 15]. Automotive firms make extensive use of such arrangements: Tesla Motors, for instance, combined alliances with suppliers, R&D partners and other manufacturers to develop its vehicles [KARA 13], while Renault relies on the Renault-Nissan-Mitsubishi Alliance and on technological networks to share complementary technologies [NIE 07].

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Within a business ecosystem, these three forms of open innovation correspond to the different directions in which knowledge circulates between the keystone and the other members of the ecosystem: from suppliers, customers, universities and training institutes towards the firm (inbound), from the firm towards other actors (outbound), and in both directions within alliances and joint projects (coupled). This typology therefore provides a relevant framework for examining how open innovation practices shape innovation performance in an automotive business ecosystem such as Renault's.

2.3. *Innovation performance*

In a context marked by intense competition, uncertainty, volatile environments and unstable customer demand [ZIZ 16], innovation has become a key organizational process [JAN 11] on which firms depend for their survival [SOZ 18]. The term performance broadly refers to the effectiveness and efficiency with which a given function is carried out [HER 17]. Applied to innovation, it designates "the ability to convert innovation inputs into outputs, and thus the ability to transform innovation capability and effort into effective market implementation" [ZIZ 16, p. 818]. Innovation performance has also been described as "the merge of resources and assets" [RAJ 18, p. 45], resulting in successful market innovations [ABD 19]. More specifically, it encompasses both the technical properties of innovations and the launch of new products on the market [ZIZ 16]. Unlike overall firm performance, innovation performance therefore focuses specifically on the outcomes of innovation efforts. It has received particular attention in business research [CHA 16, DEK 17, WAG 10] and has been examined in diverse settings, from multinationals [BAH 21, GAU 19, NUR 19] to SMEs [HAN 19, SAU 16].

Innovation performance is deeply intertwined with innovation activities and provides firms with a competitive advantage [JAN 11]. As an outcome of innovation [ROB 23], it reflects the development and dissemination of innovations through both linear and holistic approaches [EDQ 18], and is related to the behavior of the actors who hold knowledge [FEL 07]. It thus spans several levels: organizational, industrial and governmental [FOR 20]. At the micro level, it refers to the innovation outcomes of individual firms. At the meso level, it reflects the collective capacity of an industry or business ecosystem to generate and diffuse innovations. These two levels are closely interrelated. Achieving innovation performance depends on innovators' efforts to bring about market success [AAR 17] through cooperation and collaborative networks [RAD 20]. The innovation performance of each firm thus depends on the knowledge, resources and complementarities available within its ecosystem, and on its ability to combine internal R&D with external knowledge sources [CAS 06].

Whether assessed at the firm or the ecosystem level, innovation performance requires explicit criteria to be defined and measured. Its key components include R&D processes, patents and the establishment of new products [ERN 01, STU 00]. The most commonly used measures relate to patents, the market introduction of new products, process innovation and the sales generated by new products [CRA 14]. These criteria can be grouped into three complementary dimensions. Input criteria refer to investment in innovation [GRI 06], notably in R&D and ICT [HAL 13]. Process criteria concern the forms of knowledge acquisition and the design of the innovation process [CRA 14], as well as the speed and cost at which innovations are developed. Output criteria capture technological results, such as patents and the number of new products, and market results, such as the sales and market share of new products.

The choice among these measures depends on the innovative context of organizations' activities and on their market success [TID 01]. Performance frameworks differ according to the scope and nature of innovations, and must be assessed over a time frame long enough for results to materialize on the market [DRU 15]. Ultimately, it is the usefulness of products and services on the market that determines the performance of innovations [DRU 15]. Consequently, objective indicators such as patents or R&D expenditure are not equally relevant in all contexts. In assembly-oriented manufacturing ecosystems, where innovation is largely incremental and process-based, market- and cost-related indicators better reflect innovation outcomes than patent counts. For this reason, the present study measures innovation performance through the scale of Han and Li [HAN 15], which

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assesses the number, launch speed, operating costs, sales and market share of new products, as perceived by respondents relative to competitors over the last three years [KRA 90]. Innovation performance is thus captured at the firm level, while the results are interpreted in light of the business ecosystem in which firms operate.

2.4. *Development of the research hypotheses*

As firms interact actively with different parties, they gain extensive access to intangible capital, such as knowledge, external ideas, talent and technologies, which makes them more likely to generate successful innovations [GRE 16]. Scholars have therefore expressed growing interest in the effects of open innovation on innovation performance [GIA 10, SCH 12, WES 14a]. By implementing open innovation, firms have been able to broaden their range of innovative products while reducing the costs of internal R&D [GIA 10]. Well-known examples include Xerox [CHE 03b] and Procter & Gamble [DOD 06], which combined different open innovation approaches by drawing on external networks and commercializing their existing knowledge and intellectual property [GIA 10].

Open innovation, through its inbound, outbound and coupled forms, has been shown to support innovation performance [BIG 20, CHEN 14, CHE 03a, CHES 14a, CHIAN 10, DAH 10, FRI 12, GAS 06, GRE 15, HER 11, ORT 12, RAN 17]. By fostering internal technologies and incorporating external ones, firms strengthen their performance [BIG 20] and sustain a continuous flow of new product launches [BIG 21]. Within a business ecosystem, however, each form of open innovation relies on a distinct mechanism, which justifies examining their effects on innovation performance separately.

Inbound open innovation allows firms to incorporate external technologies and strengthen their performance [BIG 20]. Notably, Inauen and Schenker-Wicki [INA 11] show that inbound open innovation enhances innovation performance: collaborative linkages with customers and universities support product innovations, while open interrelations with rivals, suppliers and universities support process innovations. By interacting with customers, suppliers, competitors [LAS 12] and research institutions, firms combine complementary abilities and shared objectives, which increases their innovation performance [HUN 10, HWA 10, LAU 06]. In an automotive business ecosystem, the keystone and its members constantly draw on the knowledge of suppliers, equipment manufacturers, customers and training institutes to develop new products and improve their processes. Inbound flows should therefore improve the market and cost outcomes of new products. Hence the following hypothesis:

H1: Inbound open innovation has a positive effect on innovation performance.

Outbound open innovation relies on selling licenses and patents, managing intellectual property and leveraging internal assets to create value [BIG 20, ROT 09]. By bringing internal technologies to market through external paths, firms generate additional revenue and gain new technical and marketing opportunities, while better-positioned partners accelerate the commercialization of their innovations [DAH 10, WAL 12]. Schroll and Mild [SCH 11] further identify outbound cooperation, alongside acquisition and inbound cooperation, as one of the distinct modes through which firms engage in open innovation. Within a business ecosystem, outbound flows from the keystone towards suppliers and partners transfer technologies, standards and know-how that raise the capabilities of the whole network. They also allow unused innovations to be commercialized by better-suited organizations, generating additional returns and accelerating new product launches. Hence the following hypothesis:

H2: Outbound open innovation has a positive effect on innovation performance.

Coupled open innovation combines inbound and outbound flows and is associated with superior innovation performance outcomes [CHO 16, MAZ 12]. Successful open innovation delivers optimized costs [CAL 04], the creation of new products [GRI 09, LAU 06] and efficient novelty [STE 17]. Coupled processes are particularly suited to achieving these outcomes, as innovation benefits from knowledge transfer, interorganizational networks, knowledge spillovers and cooperative partnerships

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[FAC 20], and improves through the reciprocal integration and exchange of knowledge [HEE 22, WAN 22]. In the Renault ecosystem, the Renault-Nissan-Mitsubishi Alliance, joint projects with suppliers and collaborative programs with training institutes are typical coupled arrangements, through which partners share development costs and risks while combining complementary technologies. Hence the following hypothesis:

H3: Coupled open innovation has a positive effect on innovation performance.

The following conceptual model in Figure 1 illustrates these research hypotheses:

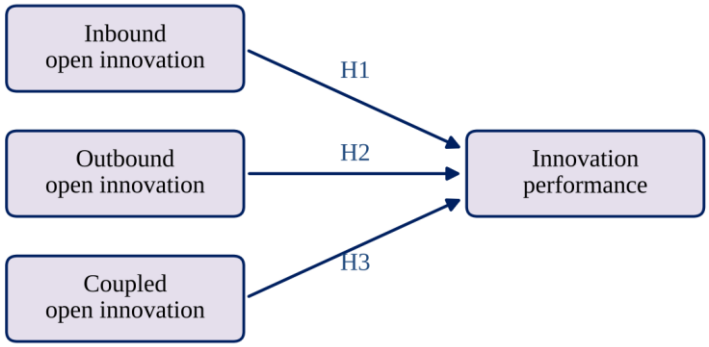


Figure 1. *Conceptual model (source: the authors)*

3. Research methodology

3.1. *Sampling and data collection*

Before presenting our research methodology, it is vital to present an overview of the automotive business ecosystem in Morocco, led by a renowned firm such as Renault. Morocco's automotive industrial policy has fostered exports and employment while strengthening local integration and sustainability, notably through an approach based on integrated industrial ecosystems, with the aim of increasing local content, exports and employment [HAK 20].

Four clusters have thus been organized around six industrial ecosystems to develop an industry geared towards the future of mobility: wiring; metal and stamping; batteries; vehicle interiors and seats; transmission, engine and powertrain; and trucks and industrial vehicles. Within this framework, two carmaker-dedicated ecosystems have emerged, one dedicated to Renault and the other to Peugeot, now part of Stellantis [AMA 23, HAH 17]. Each ecosystem is managed in collaboration with entrepreneurs, major global equipment manufacturers and the Moroccan Association for the Automotive Industry and Trade (AMICA) [AMA 23]. Within each ecosystem, a large supplier firm holds a leading position and plays an active role in its development. By fostering cooperation between competing actors, these ecosystems aim to localize the production of parts that are still imported, increase volumes, attract new investment and reduce the import content of exported products [BEN 17].

Our interest focuses more specifically on the Renault Tangier plant. Built in 2008 and launched in 2012, the plant plays the role of leader of the Moroccan automotive industry and has given new momentum to the country's production capacity, which reached 430,000 vehicles in 2018, of which 340,000 units were produced at the Tangier site [HAK 20]. In 2019, the plant produced 303,558 vehicles, 93% of which were exported [REN 19]. The company pioneered the assembly of low-cost, or entry-family, cars under the Dacia brand, thereby consolidating Morocco's position in a strategic segment that had already proved highly successful on the European market [HAK 20]. Thanks to this Entry range, the Tangier site has become a major supplier to the European market [BEN 17].

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The Tangier plant is part of Renault Morocco, which also includes the SOMACA plant in Casablanca, Renault Commerce Maroc and RCI Finance Maroc. With the Dacia and Renault brands ranking first and second respectively, the Group holds a market share above 40% in Morocco [REN 19]. Around the plant, Renault has developed a "builder ecosystem" structured around supplier development, innovation and coordinated competencies [SEB 22]. The Group is committed to raising its local integration rate to 80% in the long term, and the number of tier-1 suppliers established in the country has already tripled, from 26 to 76 [REN 21]. Tier-1 and tier-2 equipment suppliers have settled across the industrial zones of Tangier, Kenitra and Casablanca, enriching the network of automotive ecosystems [HAK 20]. Training institutions are another key component of the ecosystem. The Training Institute for Automotive Industry Professions of Tangier Med (IFMIA-TM), created through a public-private partnership between the Moroccan State and Renault, trains employees of Renault and of its partner companies; in 2018 alone, it trained 11,800 people [LAB 19]. Finally, the ecosystem is embedded in the Renault-Nissan-Mitsubishi Alliance, which allows its members to pool purchasing, share technologies and jointly finance research and development [SGS 23], while combining their complementary competencies and geographic presence [CIR 21].

Renault's Tangier ecosystem was therefore selected as the empirical setting of this study for three reasons. First, it is the leading automotive ecosystem in Morocco in terms of production, exports and market share. Second, it brings together a keystone carmaker, a dense network of suppliers and complementors, and dedicated training institutes, between which the inbound, outbound and coupled knowledge flows examined in this study take place. Third, through the Renault-Nissan-Mitsubishi Alliance, it offers a setting in which coupled open innovation is structurally embedded, making it particularly suitable for comparing the effects of the three forms of open innovation on innovation performance.

Consequently, we conducted a quantitative study, targeting actors of the automotive business ecosystem of Renault's plant in Tangier. For this purpose, we employed a non-probabilistic sampling method, focusing mainly on convenience sampling [GOL 22] of customers, employees, suppliers, experts, competitors, complementors and professional training institutes. Responses were obtained from middle managers, experts and top managers, as they are best placed to possess vital knowledge about firms' resources, strategy choices and power to respond [GRU 10], and from technicians and mechanical operators for their specialized know-how in the automotive industry.

A quantitative survey took place from 1 June 2023 to 31 January 2024, mainly through offline and online platforms (e.g., social networks such as LinkedIn). A pretest was first conducted to ensure the clarity of questions, avoid ambiguity and reduce errors and bias [SEK 16]. We assembled 196 questionnaires after removing 12 incomplete surveys. The sample size conforms to the rule of thumb of Roscoe [ROS 75], meeting the criteria of a sample size between 30 and 500 [MER 16, SEK 16].

We used SPSS (Statistical Package for the Social Sciences) to analyze the collected data, conducting the necessary tests (e.g., correlation, analysis of variance (ANOVA), regression) to test prior hypotheses and draw results for decision-making. A preliminary step was therefore carried out to prepare the data by recoding variables, tagging and creating new variables [THR 23].

3.2. *The choice of measurement scales*

For this research, we explored the influence of open innovation practices, namely inbound, outbound and coupled open innovation, on innovation performance. A seven-point Likert scale was adopted for all the measures, ranging from 1 (i.e., strongly disagree) to 7 (i.e., strongly agree), in order to facilitate their comprehension, interpretation and adaptation to specific contexts [ROS 02].

As open innovation consolidates firms' competitiveness through external knowledge to reinforce innovation and strengthen performance, three principal strategies are presented: inbound, outbound and coupled open innovation [COS 22]. These three strategies constitute the independent variables of our research. Inbound open innovation was examined through the six-item scale of Naqshbandi et al.

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[NAQ 16] and Sisodiya [SIS 08]. The inbound scale measures the sourcing and integration of external knowledge: actively searching for knowledge and technologies from research groups, universities, suppliers, customers and competitors when developing new products; combining externally developed knowledge and technologies with internal R&D; and continuously scanning the external environment for technologies, information, ideas and knowledge. These practices mainly support product innovation and, through the absorption of suppliers' and competitors' technologies, process innovation [INA 11].

Outbound open innovation was measured by the four-item scale of Jaworski and Kohli [JAW 93] and Pisano and Teece [PIS 07], which highlights the external commercialization of technologies, that is, the extent to which the organization considers its technologies (all technologies, unused technologies, relatively mature technologies or non-core technologies) as candidates for commercialization outside the firm. These practices concern the exploitation of technological innovations through other organizations, for instance through out-licensing or sales of technology [DAH 10].

The coupled open innovation scale of Ahn et al. [AHN 15], consisting of five items, measures the frequency with which the organization engaged, over the last three years, in joint knowledge creation with partners: participation in conferences and trade fairs, collaborative projects supported by regional public funding, patents shared with other organizations, informal interactions and joint doctoral theses. These practices combine non-pecuniary knowledge exchange with pecuniary co-development [FLO 19] and support the joint development of both product and process innovations.

Concurrently, innovation performance acts as the dependent variable of this research, measured through the scale of Han and Li [HAN 15]. Responses were obtained through a comparison with competitors' innovation performance over the last three years, in order to lower the risk of subjectivity [KRA 90]. This scale was chosen for its ability to capture the outcomes of new products, covering their number, launch speed, operating costs, sales and market share. It therefore reflects both the market outcomes of product innovation (sales and market share of new products) and the efficiency gains associated with process innovation (reduction in the operating costs of new products).

The measures were chosen for their quality and their exemplification of collaboration relationships in open innovation (Table 1) taking place in strategic alliances, such as the Renault-Nissan-Mitsubishi strategic alliance at the center of our study.

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Variable	Source (initial items)	Practices measured	Main type of innovation concerned
Inbound open innovation	Naqshbandi et al. [NAQ 16]; Sisodiya [SIS 08] 6 items	Search for external knowledge and technologies when developing new products; integration of external knowledge and technologies with internal R&D; scanning of the external environment	Product innovation; process innovation
Outbound open innovation	Jaworski & Kohli [JAW 93]; Pisano & Teece [PIS 07] 4 items	External commercialization of technologies (all, unused, relatively mature or non-core technologies)	Technological innovations exploited outside the firm
Coupled open innovation	Ahn et al. [AHN 15] 5 items	Participation in conferences and trade fairs; collaborative projects supported by regional public funding; patents shared with other organizations; informal interactions; joint doctoral theses	Joint product and process innovation
Innovation performance	Han & Li [HAN 15] 5 items	Number, launch speed, operating costs, sales and market share of new products, compared with competitors over the last three years	Market outcomes of product innovation; cost efficiency of process innovation

Table 1. *Measurement scales, open innovation practices and innovation performance*

4. Data analysis and results

4.1. *Data analysis*

4.1.1. *Validity of the scales: principal component analysis (PCA)*

Principal component analysis (PCA) was first conducted to ensure the validity of items used in the measures [HAI 14].

As a multivariate statistical tool, PCA reduces and excludes less relevant factors, retaining variables with significant correlations to other components. The estimated variance-covariance ratio reached 70% [CAR 09], summarizing variables into a homogeneous matrix of discernible factors while optimizing data variability with the fewest components.

We proceeded to present PCA results following four main steps:

– Step 1: Assessment of the Kaiser-Meyer-Olkin (KMO) index and the significance of Bartlett's test;

– Step 2: Confirmation of the communalities related to the quality of factor representation;

– Step 3: Conservation of the recommended factor of the Total Variance Explained (removing items weakly relevant to the total variance);

– Step 4: Evaluation of the Rotation of the Component Matrix (when presented with factor loadings unrelated to the analysis).

The KMO index exceeded 0.7 — excellent — for all four variables: "Inbound" (see Appendix 1), "Outbound" (see Appendix 2), "Coupled open innovation" (see Appendix 3) and "Innovation

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performance" (see Appendix 4). Combined with a highly significant Bartlett test (sig < 0.05), items showed medium correlation (0.4–0.6) across all four variables.

The quality of factor representations confirmed communalities above 0.5 for all four variables.

Total Variance Explained results retained two factors explaining over 70% of total variance [CAR 09].

4.1.2. *Reliability of the scales: Cronbach's alpha coefficient*

Having established validity, we assessed reliability for a more accurate, consistent presentation of the variables [HAI 14].

Reliability was evaluated via Cronbach's alpha [CRO 51], requiring a minimum of 0.7 [CHA 21], to assess response consistency across scale items and measure internal consistency through item intercorrelations [SEK 16].

This purification step ensured strong inter-item correlation, targeting an alpha above 0.7 [HAI 14]; the coefficient can be refined by removing items whose exclusion raises the overall alpha.

For "Inbound", "Outbound" and "Innovation performance" (see Appendix 5), results show a satisfactory Cronbach's alpha value; all items were maintained.

For "Coupled open innovation", the matrix showed the original value could be improved from 0.776 to 0.789 by removing one item. After these purification stages, we proceeded to test the research hypotheses.

4.2. *Results*

4.2.1. *Hypothesis testing: multiple regression*

Regression analysis, used to draw population-level inferences from sample data [SEK 16], examines how a dependent variable's variance is explained by multiple independent variables, completing the process from conceptual model to hypothesis testing [SEK 16].

Widely used in business research, multiple regression analysis examines how a dependent variable's variance is explained by more than one independent variable. It completes the research process, from the conceptual model, leading to the statement of related hypotheses and concluding with testing of these hypotheses using regression [SEK 16]. The purpose of this step is to accept or reject the proposed hypotheses:

H1: Inbound open innovation has a positive effect on innovation performance.

H2: Outbound open innovation has a positive effect on innovation performance.

H3: Coupled open innovation has a positive effect on innovation performance.

Firstly, the adjusted R^2 shows that all three dimensions of open innovation explain 54.9% of the variance in innovation performance.

Secondly, the ANOVA results present a highly significant model (p-value < 0.05).

Results of collinearity tests, via Tolerance and the Variance Inflation Factor (VIF), match the required premises (tolerance > 0.3, VIF < 3.3, see Table 2), indicating low correlation between explanatory variables and adequate model quality. The t-test confirms that the regression of the three open innovation dimensions on innovation performance is statistically significant (p-value < 0.05) and positive, with t-values above 2 [CAR 09]: 8.533, 3.350 and 2.357 for inbound, outbound and coupled open innovation respectively.

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Therefore, the model can be summarized along these lines:

$$Y = b_0 + b_1X_1 + \ldots + b_nX_n \quad [1]$$

$$\text{Innovation performance} = 0.313 + 0.588 \times \text{Inbound open innovation} + 0.234 \times \text{Outbound open innovation} + 0.172 \times \text{Coupled open innovation} \quad [2]$$

H1, H2 and H3 are therefore validated: inbound, outbound and coupled open innovation each positively affect innovation performance, acting as conditioning factors within the business ecosystem. The model is satisfactory, explaining 54.9% of the variance in innovation performance with acceptable coefficients and no sign of collinearity.

Model summary										
	R	R^2	Adjusted R^2	Std. error of the estimate	R^2 change	F change	df1	df2	Sig. F change	Durbin-Watson
Model 1	0.746	0.556	0.549	1.11812	0.556	80.226	3	192	0.000	1.533
ANOVA										
	Sum of squares	df	Mean square	F	Sig.					
Regression	300.897	3	100.299	80.226	0.000					
Residual	240.039	192	1.250							
Total	540.936	195								
Coefficients										
	B	Std. error	Beta	t	Sig.	Zero-order correlation	Partial correlation	Part correlation	Tolerance	VIF
(Constant)	0.313	0.330		0.949	0.344					
Inbound open innovation	0.588	0.069	0.513	8.533	0.000	0.699	0.524	0.410	0.640	1.562
Outbound open innovation	0.234	0.070	0.204	3.350	0.001	0.540	0.235	0.161	0.622	1.607
Coupled open innovation	0.172	0.073	0.154	2.357	0.019	0.569	0.168	0.113	0.541	1.849

Table 2. *The multiple regression analysis: the innovation performance model results*

5. Discussion

5.1. *The focal role of open innovation in the innovation performance of the automotive business ecosystem*

Following the examples presented by Moore [MOO 96], actors evolving in a business ecosystem seek first and foremost mutually beneficial long-term business relationships. Companies develop strategies and implement innovations that support or complement others' work in the same ecosystem, taking into consideration "the big picture" in which every actor plays a profitable role [MOO 96]. The

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automotive business ecosystem of Renault in Morocco has been established to gain visible competitiveness in manufacturing activities, choosing the Moroccan geography as a means to lower costs [CHE 11]. The creation of a "builder ecosystem" provides key advantages of flexible supply, access to various stakeholders (e.g., experienced suppliers, professional training institutes, developers) and a pool of complementary competencies [SEB 22].

As organizations delve into knowledge beyond traditional boundaries, they extend their internal knowledge foundations and develop their interorganizational ties, thereby sustaining the open innovation model [CHE 06a, GRA 04, NYS 20]. The combination of internal and external sources of knowledge is at the core of the innovation process [BOG 17] and underpins the inbound and outbound exploitation of open innovation [CHE 03c, GRA 04]. Nevertheless, internal operations remain at the heart of open innovation [NYS 20], generating outside-in and inside-out strategies [BOG 18]. The results emphasize the predominant role of all three dimensions of open innovation in the context of the automotive business ecosystem, which jointly explain 54.9% of the variance in innovation performance. Given its nature, the automotive industry is highly innovative and necessitates the involvement of multiple agents in the manufacturing of vehicles. The actors involved in this ecosystem range from customers, employees, supplementary manufacturers and rivals (e.g., the Stellantis Group, located in Kenitra) to suppliers and complementors. Their domains vary from manufacturing, materials, infotainment and ICT to automotive parts supply, logistics, marketing and sales.

Moreover, companies are turning to multiple agents, employing pecuniary and non-pecuniary strategies, hence promoting knowledge sharing and expanding their organizational boundaries beyond traditional models of closed innovation [CHES 14c, CHE 07, LIU 19]. As a multi-agent model, open innovation relies on the input of customers and communities as a primary source of knowledge to address organizational challenges and fast-evolving technological demands [HAR 16]. By adopting an open innovation model, firms can attain higher innovation performance [BIG 20, COS 22, GRE 15, LEI 12, MAR 12, RAN 17], increasing sales of new products and advancing their competitiveness [FLO 19]. As such, a growing base of actors is needed to take part in and purposefully manage knowledge flows [ALA 22, LIU 19, ZHA 23a], aligning product users and producers [NYS 20] and improving user value [ALM 10]. The contributions of the three dimensions of open innovation are nevertheless unequal: inbound open innovation has the strongest effect ($B = 0.588$; $\beta = 0.513$), followed by outbound ($B = 0.234$; $\beta = 0.204$) and coupled open innovation ($B = 0.172$; $\beta = 0.154$). These differences can be understood by considering the types of innovation that each form of openness generates for the firms of the ecosystem.

As our study centers on a coupled form of open innovation established through an alliance [ENK 09, KAT 02, ZHA 23b], through which the ecosystem acquires the technologies needed for its manufacturing activities in order to ensure a competitive advantage in markets [CHO 16], the results sustain a positive effect of coupled open innovation on innovation performance. Coupled open innovation sets the framework for combined inbound and outbound activities led by cooperative partners [KARA 13]. As is the case with major companies, Renault supports interorganizational collaborations, mainly through alliances (such as the Renault-Nissan-Mitsubishi Alliance) and technological networks, in order to share the competitive advantage of product innovation and complementary technology [NIE 07]. Moreover, coupled open innovation has proven beneficial to firms, mainly through collaborative efforts with other organizations, resulting in improved knowledge trade, superior technological efficiency and multiplied revenues from shared innovation [BIG 20]. Coupling open innovation processes sharpens cooperative efforts through reciprocal knowledge exchange, developing new knowledge and novelties for better innovations [GRE 15]. However, the effect of coupled open innovation remains the weakest of the three. This can be explained by the division of innovation activities within the Group: joint product and technology development mainly takes place in R&D centers and laboratories located outside Morocco, whereas the Tangier plant is primarily dedicated to manufacturing. The coupled practices measured at the local level, such as

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participation in conferences and trade fairs, publicly funded collaborative projects and shared patents, are therefore less widespread among the ecosystem's actors.

By contrast, this study sheds light on the leading position of inbound open innovation through the lens of manufacturing automotive business ecosystems. This distinction serves as a starting point for studying the development of inbound practices in appropriate innovation settings. As an assembly plant, the Tangier site is less concerned with upstream R&D and design than with the application of innovative procedures, the assembly of technical components, and the production and market introduction of finished vehicles. Innovation in this setting therefore mainly takes the form of manufacturing and process innovation, complemented by incremental product innovations embedded in new models. By exploiting the novelties of other actors [CHE 06a], firms adopting inbound open innovation use their capabilities and their relations with external parties to manage internal knowledge and external resources and to alleviate inefficiencies [BIG 20]. In this respect, the carmaker relies in particular on the expertise, technical knowledge and new technologies of its tier-1 suppliers to develop products and improve processes [WIL 18]. Outside-in innovation also centers on co-creation with users and consumers [BOG 10, NYS 20]. By fostering a co-creation process, firms benefit from a base of users' ideas, continuously renewing the creation of products and services and building attachment to the organization [BRU 14, PRA 00]. The results underscore the paramount role of inbound open innovation compared with the other two categories. With the highest coefficient (B = 0.588; β = 0.513), it reflects collaborations with external participants, inward IP licensing, networking, outsourced R&D and customer participation [RAN 17, VAN 09]. Moreover, inbound activities serve as a hallmark of open innovation practices in automotive contexts [WES 14b, WIL 18]. This sub-form of open innovation is crucial to achieving innovation performance, as organizations acquire external knowledge and technology that promote internal innovation [CHE 06a, RAN 17], thereby improving the sales, market share and operating costs of new products captured by our performance measure.

Nonetheless, the results also confirm a positive effect of outbound open innovation on innovation performance (B = 0.234; β = 0.204). Given Renault's position as one of the leading companies in the automotive industry worldwide, the Group relies on a large platform of innovations and technologies to face the challenges of increasing requirements, technological obsolescence and risk management. The evolution of the ICT landscape is a key factor requiring the leading actors of business ecosystems, as the main sources of technology flows, to manage dormant or irrelevant innovations. Outbound open innovation uses internal technology and knowledge shared with external actors [CHE 06a], involving employee participation, outward IP licensing and ventures [RAN 17, VAN 09]. This specific framework seeks to exploit the possibilities and potential of innovation by creating additional value through appropriate channels to reach the market [CHE 06a, RAN 17]. This form of open innovation is therefore adopted to identify possible ways of commercializing unused innovations through better-suited organizations [DEM 12, KARL 13, SPI 11]. Within the Moroccan ecosystem, these outflows mainly take the form of technologies, standards and know-how transferred from the keystone to its suppliers, which upgrade the technological capabilities of local partners.

5.2. *Innovation performance at the ecosystem level, the Tangier plant*

While our data capture innovation performance at the firm level, contextual evidence shows how these open innovation practices translate into collective performance at the ecosystem level. At the level of the Tangier site, the growth of production capacity, which reached 340,000 vehicles in 2018 [HAK 20], and the export of 93% of the plant's output [REN 19] illustrate the market performance of the entry-family vehicles produced by the ecosystem. The increase in the number of tier-1 suppliers established in the country, from 26 to 76, and the objective of raising the local integration rate to 80% [REN 21] suggest that inbound flows between the keystone and its suppliers also translate into the development of local capabilities. Training institutions contribute to this collective performance: by training employees of Renault and of its partner companies, the IFMIA-TM diffuses process knowledge, such as maintenance, manufacturing, logistics and lean practices, across the ecosystem [LAB 19].

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At the national level, the success of Renault's ecosystem has positioned Morocco as a privileged industrial platform and attracted further carmakers and equipment manufacturers to the industrial zones of Tangier, Kenitra and Casablanca [HAK 20]. The innovation performance generated within Renault's ecosystem thus spills over to the wider Moroccan automotive industry, contributing to the localization of parts production and to the reduction of the import content of exported vehicles [BEN 17]. Taken together, these elements suggest that, in an emerging-economy "builder ecosystem", innovation performance at the firm level and at the ecosystem level reinforce each other: the inbound absorption of external knowledge improves the market and cost outcomes of firms, while the resulting upgrading of suppliers and skills strengthens the collective capacity of the ecosystem to produce and export innovative vehicles.

6. Conclusion

Globalization, the economic crisis and industrial restructuring have had a substantial influence on overall automotive production, prompting companies to choose three main sites for their manufacturing activities: Mexico for North American carmakers, Thailand or Indonesia for Southeast Asian carmakers, and Morocco or Egypt for European carmakers [SEB 20]. As such, the Moroccan automotive industry is an example of a shifted value chain, designed to gain a visible advantage through reduced costs and shorter supply-chain lead times and to secure the procurement of global manufacturers [SEB 20]. While the Renault-Nissan-Mitsubishi Alliance was met with skepticism at its inception, it has proved to be one of the world's leading manufacturers of electric vehicles [CIR 21]. Two main carmaker-led business ecosystems have since settled in Morocco, led respectively by the Renault Group and by Stellantis.

Originating in the biological sciences, the concept of business ecosystem draws on the analogy of coevolving species, linked by interdependent relationships and coexisting in a productive and sustainable value-creation environment [ADN 13b, IAN 04b, MOO 93]. Open innovation has been extensively studied in domains such as ICT, biotechnology and pharmaceuticals [CHE 06b, DIA 06]. The automotive industry, one of the most innovative, faces two main challenges: on the one hand, the growing demands and requirements of price-sensitive customers; on the other hand, the technology fusion needed to deliver the final product, which is pivotal in this industry [DEM 12]. The automotive domain is thus driven by globalization, technology fusion, intense innovation and cost pressure, all of which motivate cross-boundary collaborations and open innovation practices [GAS 06, ILI 10].

Using seven-point Likert scales, we measured the openness of innovation practices at the inbound, outbound and coupled levels, as well as innovation performance, among the actors of Renault's automotive business ecosystem, including customers, employees, suppliers, experts, competitors, complementors and specialized training institutes. The main results highlight the influence of open innovation activities on innovation performance [CHIAR 10, COS 22]. As our study takes place within the strategic alliance linking Renault, Nissan and Mitsubishi, which mainly fosters innovation cooperation through alliances and joint ventures, coupled open innovation can be regarded as a generic strategy of the Renault Group [MAZ 12]. This is also the case for Tesla Motors, which coupled open innovation processes through various alliances to optimize battery capacity and refine sporting performance [KARA 13], and of the Italian firm Pininfarina, which centered its technology and design innovation on collaborations with prestigious carmakers such as Renault, Ferrari, Maserati, Bentley and Ford [DEM 12]. While all three dimensions of open innovation have a significant and positive impact on innovation performance, inbound open innovation occupies the foremost position in improving the innovation performance of the automotive business ecosystem, followed by outbound open innovation, with coupled open innovation in last place. Inbound open innovation provides organizations with access to the technologies of external actors [DEM 12], harnessing external inflows through contractual agreements, mutual license exploitation and alliances. Nevertheless, alliances remain the preferred strategy for long-term and substantial projects.

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By adopting open innovation, firms seek strategic flexibility to stimulate innovation and meet customers' demands and market standards [GAS 04]. Widely adopted by well-established companies, it has produced exemplary positive effects, as illustrated by Intel, IBM, Lucent and P&G [CHE 03a, DOD 06, HUS 06]. The pervasiveness of open innovation in business ecosystems has had a manifest positive effect on innovation performance [CHE 06b]. It leads to closer relations with actors such as suppliers, shortening the time-to-market of new products and enhancing their quality, and with research groups, providing a better understanding of market trends and innovation techniques and improving managerial and technological forecasting [GRE 15]. Inbound open innovation, in particular, involves importing knowledge, ideas and technological capital through collaboration [DEM 12] and has a strong effect on innovation performance [BOG 17, KV 22]. It has been shown to support R&D management and to improve innovation performance through the innovation process and the share of new products [INA 11]. Our study shows that open innovation enhances innovation performance in automotive business ecosystems, especially those oriented towards manufacturing activities and known as "builder ecosystems". This strategy attracts additional investors and stakeholders who complement the business ecosystem, enlarging the scope of technological potential and innovation exchanges.

Compared with the other automotive ecosystems in Morocco, Renault's ecosystem presents several distinctive features. First, unlike the six component-based ecosystems (wiring, metal and stamping, batteries, vehicle interiors and seats, powertrain, and trucks and industrial vehicles), each of which is led by a large supplier firm [BEN 17], it is organized around a carmaker acting as a keystone, which coordinates suppliers, complementors and training institutes around the production of complete vehicles. Second, it is the oldest and largest carmaker ecosystem in the country: rooted in the historical SOMACA plant and strengthened by the Tangier plant, it accounts for the bulk of national production capacity [HAK 20] and for a market share above 40% [REN 19], whereas the Stellantis ecosystem, located in Kenitra, emerged more recently within the same industrial policy framework [HAH 17]. Third, it is specialized in entry-family vehicles that are largely exported to Europe [BEN 17], which places cost efficiency and process innovation at the heart of its innovation performance. Finally, it combines a dedicated training institute, the IFMIA-TM, with membership in a global strategic alliance, offering its actors both local capability building and access to the Alliance's technological resources.

Several lessons can be drawn from these findings. For researchers, the study shows that inbound, outbound and coupled open innovation jointly, but unequally, condition innovation performance within manufacturing-based automotive ecosystems, and that the relative weight of each dimension depends on the position of the ecosystem in the value chain: in an assembly-led ecosystem, the absorption of external knowledge matters more than joint R&D. For managers, it suggests that strengthening relationships with suppliers, customers and training institutes is the most effective lever for improving the sales, market share and costs of new products, while coupled practices should be developed locally rather than confined to the Alliance's foreign R&D centers. For policymakers, it highlights that supplier development, local integration and training are not only industrial objectives but also channels through which open innovation improves the performance of the whole ecosystem. Beyond the Moroccan case, this pattern is likely relevant to other emerging economies building similar "builder ecosystems" around assembly-led automotive clusters, such as Turkey, South Africa or Mexico.

This study therefore provides an important source of information on the nature of the open innovation practices employed in automotive business ecosystems, especially those specialized in manufacturing activities. It helps to understand actors' innovation strategies in innovative environments, in order to improve their structure and to build stronger collaborations with external actors. Our research bridges a gap in the study of open innovation in industrial settings, thereby enriching the literature on innovation and business ecosystems. Nevertheless, our research faced reticence from participants working for automotive companies, owing to restricted authorization for external exchanges and compliance with non-disclosure agreements (NDAs). The results are inferred from a convenience sample, which limits their generalization. Moreover, innovation performance was measured at the firm level through respondents' perceptions, and the relatively weak effect of coupled

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open innovation calls for further investigation. Further research could explore open innovation through a qualitative study, in order to complement the structure of the automotive business ecosystem with idiosyncratic elements relevant to "builder ecosystems", and could compare Renault's ecosystem with the Stellantis ecosystem and with other emerging automotive ecosystems to test the transferability of this model.

Appendices

Appendix 1. *PCA results: inbound open innovation*

KMO Index and Bartlett's Test		
Kaiser-Meyer-Olkin Index for Assessing Sample Adequacy		0.896
Bartlett's Test of Sphericity	Approximate Chi-Square	698.909
	Degrees of Freedom (df)	15
	Significance	<0.001

Table 3. *KMO index and Bartlett's test – inbound open innovation*

Total Variance Explained									
Component	Initial Eigenvalues			Extracted Sums of Squared Loadings			Rotated Sums of Squared Loadings		
	Total	% of Variance	Cumulative Percentage of Variance	Total	% of Variance	Cumulative Percentage of Variance	Total	% of Variance	Cumulative Percentage of Variance
1	4.096	68.262	68.262	4.096	68.262	68.262	2.657	44.281	44.281
2	0.549	9.145	77.407	0.549	9.145	77.407	1.988	33.125	77.407
3	0.444	7.408	84.815						
4	0.369	6.153	90.968						
5	0.316	5.264	96.233						
6	0.226	3.767	100.000						

Rotation of the Component Matrix		
	Component	
	1	2
“My organization actively seeks external sources of knowledge and technology—such as research groups, universities, suppliers, clients, and competitors—when developing new products.”	0.894	0.185
“My organization often brings in knowledge and technologies developed externally to use them in conjunction with our own R&D.”	0.753	0.391
“My organization constantly analyzes the external environment in search of inputs such as technology, information, ideas, knowledge, and so on.”	0.698	0.459
“My organization seeks technologies and patents from other companies, research groups, or universities.”	0.602	0.566
“My organization purchases external intellectual property to use in our own R&D.”	0.237	0.920
“My organization believes it is beneficial to use external sources—such as research groups, universities, suppliers, clients, and competitors—to complement its own R&D.”	0.620	0.650

Table 4. *Total variance explained and rotation of the component matrix – inbound open innovation*

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Appendix 2. *PCA results: outbound open innovation*

KMO Index and Bartlett's Test		
Kaiser-Meyer-Olkin Index for Assessing Sample Adequacy		0.791
Bartlett's Test of Sphericity	Approximate Chi-Square	291.716
	Degrees of Freedom (df)	6
	Significance	<0.001

Table 5. *KMO index and Bartlett's test – outbound open innovation*

Total Variance Explained									
Component	Initial Eigenvalues			Extracted Sums of Squared Loadings			Rotated Sums of Squared Loadings		
	Total	% of Variance	Cumulative Percentage of Variance	Total	% of Variance	Cumulative Percentage of Variance	Total	% of Variance	Cumulative Percentage of Variance
1	2.661	66.518	66.518	2.661	66.518	66.518	1.647	41.169	41.169
2	0.574	14.358	80.876	0.574	14.358	80.876	1.588	39.707	80.876
3	0.429	10.715	91.591						
4	0.336	8.409	100.000						

Table 6. *Total variance explained – outbound open innovation*

Appendix 3. *PCA results: coupled open innovation*

KMO Index and Bartlett's Test		
Kaiser-Meyer-Olkin Index for Assessing Sample Adequacy		0.820
Bartlett's Test of Sphericity	Approximate Chi-Square	409.744
	Degrees of Freedom (df)	10
	Significance	<0.001

Table 7. *KMO index and Bartlett's test – coupled open innovation*

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Total Variance Explained									
Component	Initial Eigenvalues			Extracted Sums of Squared Loadings			Rotated Sums of Squared Loadings		
	Total	% of Variance	Cumulative Percentage of Variance	Total	% of Variance	Cumulative Percentage of Variance	Total	% of Variance	Cumulative Percentage of Variance
1	3.118	62.358	62.358	3.118	62.358	62.358	2.392	47.842	47.842
2	0.743	14.858	77.215	0.743	14.858	77.215	1.469	29.374	77.215
3	0.480	9.601	86.816						
4	0.370	7.392	94.208						
5	0.290	5.792	100.000						

Table 8. *Total variance explained – coupled open innovation*

Rotation of the Component Matrix		
	Component	
	1	2
Participation in conferences and trade fairs	0.907	0.024
Collaborative projects supported by regional public funding	0.762	0.353
Patents shared with other organizations	0.697	0.368
Informal interactions with other organizations	0.687	0.551
Joint doctoral theses	0.177	0.951

Table 9. *Rotation of the component matrix – coupled open innovation*

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Appendix 4. *PCA results: innovation performance*

KMO Index and Bartlett's Test		
Kaiser-Meyer-Olkin Index for Assessing Sample Adequacy		0.822
Bartlett's Test of Sphericity	Approximate Chi-Square	656.667
	Degrees of Freedom (df)	10
	Significance	<0.001

Table 10. *KMO index and Bartlett's test – innovation performance*

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative Percentage of Variance	Total	% of Variance	Cumulative Percentage of Variance	Total	% of Variance	Cumulative Percentage of Variance
1	3.655	73.090	73.090	3.655	73.090	73.090	2.285	45.710	45.710
2	0.523	10.461	83.551	0.523	10.461	83.551	1.892	37.842	83.551
3	0.409	8.184	91.735						
4	0.229	4.581	96.316						
5	0.184	3.684	100.000						

Table 11. *Total variance explained – innovation performance*

Rotation of the Component Matrix		
	Component	
	1	2
Innovation Performance – Increasingly higher market share of new products	0.859	0.331
Innovation Performance – Reduction in the operating costs of new products	0.820	0.326
Innovation Performance – Increase in sales of new products	0.764	0.475
Innovation Performance – Increase in the number of new products	0.324	0.890
Innovation Performance – Speed of launching new products	0.432	0.812

Table 12. *Rotation of the component matrix – innovation performance*

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Appendix 5. *Cronbach's alpha results: inbound open innovation, outbound open innovation and innovation performance*

	Reliability statistics		
	Cronbach's alpha	Cronbach's alpha based on standardized items	Number of items
The inbound open innovation scale	0.838	0.838	3
The outbound open innovation scale	0.830	0.832	4
The innovation performance scale	0.880	0.880	3

Table 13. *Reliability statistics – inbound, outbound open innovation and innovation performance*

Appendix 6. *Cronbach's alpha results: coupled open innovation*

Reliability statistics			
Cronbach's alpha	Cronbach's alpha based on standardized items	Number of items	Cronbach's alpha if an item is deleted
0.776	0.780	4	0.789

Table 14. *Reliability statistics – coupled open innovation*

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