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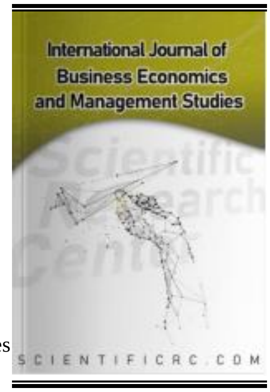

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Innovative Strategy for an Integrated Lathe Machine with the Capability of Generating Stable and Controllable Rotary Motion for Cutting Tools: A Case Study of Tariqat Sanat Mazandaran

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Abstract

his paper presents an integrated lathe machine in which a coordinated assembly of hydraulic, mechanical, and electronic components is designed as a unified and coaxial system to provide precise, stable, and controllable rotary motion for the cutting tool. In this system, power is generated by a hydraulic power unit and converted into rotary motion through a hydraulic motor. The output of the hydraulic motor is transmitted to a gearbox, where speed and torque are adjusted before being transferred to the main shaft. The lathe shaft is positioned directly in line with the gearbox output, while the spindle collet attached to the shaft securely holds the cutting tool with high rigidity and precision. The rotational speed of the shaft and the overall synchronization of the system are controlled through an inverter and a central electrical control panel, ensuring constant spindle speed, torque, and operating conditions throughout the machining process. The integration of these components into a compact, coaxial structure enables efficient power transmission with minimal energy loss, vibration, or harmful oscillation. As a result, the machine is capable of performing turning operations with superior surface quality, high dimensional accuracy, and stable performance under varying load conditions. In addition to improving operational efficiency and reducing component wear, the integrated design simplifies machine operation and minimizes the need for auxiliary standalone equipment. Owing to its stable performance, consistent power output, and precise control capability, the proposed machine offers practical applications across a wide range of metal machining industries and the manufacturing of rotary components.

Keywords: Innovative Strategy; Integrated Lathe Machine; Stable Rotary Motion; Cutting Tool; Modern Business Model.

Introduction

Innovation and creativity are fundamental drivers of success and sustainable growth in the development of emerging technologies within today's highly competitive marketplace. From product formulation and packaging design to marketing strategies, the adoption of advanced technologies, and the commercialization of innovative products, every stage requires an innovative perspective. Organizations that consistently respond to evolving market demands through creativity not only achieve greater market share but also strengthen long-term customer trust and loyalty.

Previous studies have confirmed the positive impact of product innovation on revenue growth and profitability. However, the profitability of industrial firms is not, on average, significantly influenced by service innovation activities, largely because of the challenges associated with managing the costs of service innovation. Interestingly, while service innovations tend to enhance their own profitability, they may adversely affect the profitability of product innovations. Factors that have traditionally hindered the financial success of product innovation may, conversely, provide effective support for service innovation initiatives (Eggert et al., 2014).

In conventional turning systems commonly employed in workshops and industrial manufacturing facilities, spindle rotation, torque generation, speed regulation, and hydraulic power supply are typically provided by a collection of independent machines and auxiliary equipment. This fragmented architecture results in insufficient coordination among the mechanical, hydraulic, and electronic subsystems. Consequently, machine operators are required to perform separate and often complex adjustments for each stage of the machining process.

Existing systems generally consist of a conventional lathe integrated with a hydraulic power unit, hydraulic motor, connecting hoses, a separate electrical control cabinet, and independent speed-control equipment. These components operate as isolated units rather than as an integrated system, leading to several operational deficiencies, including reduced surface finish quality, unstable spindle rotational speed, limited real-time torque control, and accelerated wear of mechanical components.

One of the most significant shortcomings of conventional lathe systems is the absence of an accurate and reliable speed-control mechanism. Many older machines rely on simple mechanical or electromechanical methods for speed adjustment, which are unable to maintain stable performance under varying load conditions. As a result, power loss, spindle vibration, and undesirable speed fluctuations frequently occur during machining operations. Furthermore, the lack of an inverter capable of coordinating motor speed with hydraulic power causes rotational instability and machining inaccuracies, negatively affecting surface quality, dimensional precision, and process repeatability. In addition, inadequate coordination between the hydraulic motor output and the mechanical characteristics of the spindle shaft and collet generates unbalanced loading, excessive heat generation, and premature component deterioration.

Operational complexity represents another major limitation of existing systems. Operators must simultaneously manage both the lathe machine and the separate hydraulic power unit. Whenever the workpiece, cutting tool, or material changes, both systems require independent adjustment and calibration. This not only prolongs production time but also increases the likelihood of human error. Many operators encounter difficulties when working with standalone hydraulic systems because synchronizing hydraulic pressure, motor power, and machining conditions requires considerable technical expertise. As indicated in the supporting documentation, operators must independently configure machining parameters, hydraulic settings, and machine adjustments according to engineering drawings to ensure successful machining operations.

Another critical issue associated with conventional systems is their high operational cost and limited productivity. The use of two independent machines—one for machining operations and another for hydraulic power generation—not only substantially increases the initial investment but also doubles maintenance and servicing costs. Moreover, connecting these separate systems through multiple hoses, electrical cables, and mechanical interfaces introduces numerous potential failure points. Electronic interference, hydraulic leakage, increased vulnerability to mechanical impact, and accelerated component wear are among the consequences of this distributed configuration. The supporting documentation likewise emphasizes that the conventional approach requires two separate machines, resulting in higher costs and greater operational complexity.

Given the increasing industrial demand for integrated, reliable, cost-effective, and highly controllable machining systems, it has become evident that existing technologies are no longer capable of meeting modern manufacturing requirements. Accordingly, the primary objective of the present invention is to design and develop a fully integrated machining system in which the spindle shaft and collet, gearbox, hydraulic motor, hydraulic power unit, inverter, and central control panel are incorporated into a single coordinated structure. This integrated configuration enables all turning operations to be performed accurately, consistently, and efficiently without the need for multiple auxiliary devices. In addition to reducing manufacturing and maintenance costs, the proposed system enhances operational efficiency, simplifies machine operation, extends equipment service life, and facilitates broader implementation in industrial production lines.

Furthermore, the invention aims to provide precise tool selection, material-specific parameter adjustment, and coordinated control of hydraulic and electronic subsystems to overcome the limitations of existing technologies.

Therefore, the principal research question addressed in this study is:

How can an innovative strategy for an integrated lathe machine capable of generating stable and controllable rotary motion for cutting tools contribute to the development of modern business models?

Lecture review

investigated the role of the organizational environment in fostering an innovation culture and its subsequent effects on marketing innovation, product innovation, and market performance. Their descriptive correlational study demonstrated that the organizational environment significantly influences innovation culture. Furthermore, innovation culture enhances the performance of small private firms through both product and marketing innovation. Their findings also indicate that both the internal and external organizational environments positively affect innovation culture, marketing innovation, and product innovation, thereby contributing to improved market performance.

Over the past decades, lathe machines and machining technologies have undergone considerable advancements in various areas, including workpiece holding systems, automatic positioning mechanisms, advanced material removal techniques, and fully automated machining systems. Despite these developments, the majority of patented inventions in the machine-tool industry have focused on improving a single component of the turning process, such as chuck designs, workpiece holding devices, specialized cutting methods, or dedicated machines for machining specific materials. In many of these innovations, primary attention has been directed toward tool holders, workpiece fixtures, or machining techniques, while the integration of hydraulic, mechanical, and electronic power systems into a unified platform has received comparatively little attention.

Conventional lathe machines generally employ traditional mechanisms for power transmission, spindle rotation, and speed control. In typical systems, spindle motion is generated by standard electric motors and conventional gearboxes, whereas hydraulic power is used only for auxiliary functions, such as actuating chucks or secondary axes. Consequently, these systems lack functional integration among the drive motor, hydraulic subsystem, electronic control system, and spindle assembly. Moreover, spindle speed regulation, torque adjustment, and hydraulic power management are performed through separate subsystems, requiring operators to simultaneously manage multiple independent units. As highlighted in the supporting technical documentation, coordinating these components inevitably increases operational complexity, raises costs, and reduces machining accuracy.

The present study introduces an approach that fundamentally differs from previous technologies by proposing a fully integrated solution in which the spindle shaft and collet assembly, hydraulic motor, hydraulic power unit, gearbox, inverter, and electrical control panel are incorporated into a single machine. The principal innovation of this invention lies in the seamless integration of three critical subsystems—mechanical, hydraulic, and electronic—within one coordinated architecture, a feature absent from existing technologies. The following sections outline the technical distinctions between the proposed invention and representative prior patents.

reported that innovation is more prevalent in highly dynamic industries and that the interaction among organizational knowledge, industry dynamism, and innovation significantly influences firm performance.

One relevant domestic patent, entitled "Irregular Hydraulic Four-Jaw Chuck for a Lathe with Automatic Workpiece Centering" (Patent No. 101995), focuses exclusively on the workpiece-holding mechanism (four-jaw chuck) and the automatic centering process. Its primary objective is to reduce setup time, eliminate manual operator intervention, and automate workpiece alignment. The system consists of hydraulic cylinders, pistons, solenoid valves, a PLC controller, a digital keypad, and workpiece-holding mechanisms.

The proposed invention differs substantially from this patent in several respects. First, the cited patent concentrates solely on the workpiece-holding system, whereas the present invention integrates the complete drive mechanism, including the spindle shaft, spindle collet, gearbox, hydraulic motor, hydraulic power unit, and inverter. Second, the earlier invention does not incorporate any rotational drive system, power transmission mechanism, spindle speed control, or integrated drive assembly; the chuck merely functions as a clamping device. Third, hydraulic power in the previous invention is used only to actuate the chuck jaws, while the proposed system utilizes hydraulic power as the primary source of spindle rotation and torque generation. Furthermore, the PLC controller in the earlier patent regulates only jaw positioning, whereas the present invention provides coordinated control of spindle speed, torque, and driving power. Finally, the previous invention does not address uniform power transmission, spindle rotational accuracy, vibration reduction, or complete system integration. Therefore, its technical scope and functional objectives are fundamentally different from those of the proposed invention.

examined the role of technological innovation capabilities in enhancing the innovation performance of knowledge-based companies located in the Science and Technology Park of the University of Tehran. Their findings revealed that strategic planning, research and development, resource allocation, marketing, and organizational learning capabilities significantly improve innovation performance. In addition, effective resource allocation and R&D capabilities substantially enhance new product introduction.

Another domestic patent, entitled "Rotary Surface Peeling Machine Using Electric Arc" (Patent No. 113357), describes a specialized surface-removal process employing electric arc gouging and compressed air to remove molten metal. This invention is essentially a hybrid welding–gouging system designed to create grooves or remove unwanted surface layers rather than perform precision turning operations. Fundamentally, it represents a thermal material-removal process rather than a mechanical power-transmission system.

Moreover, in the rotary peeling machine, rotational motion is applied only to rotate the workpiece, whereas in the proposed invention spindle rotation and power transmission constitute the core operational mechanism. The earlier invention contains no hydraulic motor, hydraulic power unit, gearbox, or spindle collet. Its material removal process is based on thermal melting of metal, while the proposed machine performs precise mechanical rotary cutting. Furthermore, the rotating component in the previous invention serves only to rotate the workpiece, whereas the proposed system generates controlled rotary motion for the cutting tool itself. Consequently, the earlier invention cannot be regarded as a complete mechanical lathe and belongs to an entirely different technical field. Therefore, there is no significant structural, functional, or technological overlap between the two systems.

Another domestic patent, entitled "Sphere-Turning Device Installable on a Conventional Lathe Machine" (Patent No. 65852), describes a specialized attachment designed to be mounted on an existing conventional lathe to enable the machining of spherical components. Its primary function is to modify the tool's center of rotation in order to generate a spherical cutting path. This invention is essentially an auxiliary module or attachment rather than an independent machine tool. The conventional lathe remains the primary machining platform, whereas the proposed invention constitutes a complete machine equipped with an integrated drive and control system.

Furthermore, the cited patent contains no hydraulic power system, dedicated spindle shaft, gearbox, hydraulic motor, or specially designed spindle collet. Its sole purpose is to alter the tool trajectory to facilitate spherical machining, whereas the proposed machine establishes a comprehensive infrastructure for power generation, rotational speed control, and power transmission. The sphere-turning attachment relies entirely on the power supplied by the host lathe machine, while the proposed invention incorporates its own integrated power-generation and drive system. This distinction clearly demonstrates that the proposed invention operates at the level of a complete machine tool rather than as an auxiliary accessory.

Another domestic patent, entitled "Fully Automatic Ceramic Billet Turning Machine for Manufacturing Ceramic Balls" (Patent No. 106029), relates to a special-purpose machine developed specifically for machining ceramic billets into ceramic balls. Its fully automatic operation is limited to the specialized production process of ceramic ball manufacturing. Accordingly, this system is designed for a single material (ceramic) and a highly specific manufacturing application.

The machine architecture is based on complete automation of the machining cycle for a particular material and is therefore unsuitable for general-purpose turning operations. Moreover, it lacks the integrated hydraulic–electronic drive architecture proposed in the present invention. In the cited patent, hydraulic power is employed only to automate specific process functions, and it does not incorporate an integrated power-transmission configuration comparable to that of the proposed system. In contrast, the present invention is designed as a versatile, general-purpose machine tool capable of performing a broad range of turning operations, whereas the cited patent represents a dedicated special-purpose machine. Furthermore, its spindle speed control, torque management, spindle collet configuration, and power-transmission mechanism differ substantially from those of the proposed invention, resulting in a considerably narrower operational scope. Therefore, in terms of functionality, technical architecture, and industrial applicability, the cited invention cannot be regarded as technically equivalent or comparable to the proposed integrated lathe system.

Research Methods

The operational methodology of the proposed system is based on the coordinated interaction among the hydraulic subsystem, power transmission mechanism, tool-holding assembly, and electronic control system. The machine is designed to enable operators to perform turning operations with minimal manual intervention and without requiring complex adjustments while maintaining high machining accuracy and operational stability.

The operating cycle begins with the activation of the central control system. The operator switches on the main electrical control panel, placing the inverter in standby mode. At this stage, all protection circuits, control elements, and monitoring sensors are initialized and stabilized, preparing the system to receive operational commands.

Once the machine reaches the ready state, the operator activates the hydraulic power unit. The hydraulic pump generates the high-pressure hydraulic oil required to drive the hydraulic motor. The pressurized oil is delivered through high-pressure pipelines and controlled hydraulic connections to the hydraulic motor, which converts the hydraulic energy into the initial rotary motion.

The rotational output of the hydraulic motor is then transmitted to the gearbox, where the selected transmission ratio adjusts the rotational speed and torque to values appropriate for the intended turning operation. At this stage, the operator can accurately regulate the spindle speed through the inverter, thereby establishing the desired machining conditions before the cutting process begins.

After the spindle speed has been configured, the cutting tool is installed in the spindle collet and secured using the precision locking mechanism. The collet is specifically designed to maintain perfect concentric alignment between the cutting tool and the spindle axis, thereby minimizing runout, vibration, and positioning errors.

Following proper tool installation, the workpiece is positioned relative to the cutting tool, and the initial cutting engagement is established according to the machining requirements. Once material removal begins, the inverter continuously regulates the motor speed to prevent sudden fluctuations in spindle rotation. Even under transient increases in cutting load, the control system maintains a constant spindle speed, thereby ensuring machining stability, superior surface finish, and consistent dimensional accuracy.

Throughout the machining operation, hydraulic oil continuously flows from the hydraulic power unit to the hydraulic motor under stable pressure conditions. Simultaneously, the cooling system integrated within the hydraulic power unit maintains the operating temperature within the specified range. The stable hydraulic pressure ensures constant torque output from the hydraulic motor, enabling the gearbox to transmit power efficiently and uniformly to the spindle shaft. This coordinated interaction among the hydraulic subsystem, power transmission mechanism, and tool-holding assembly facilitates uninterrupted machining with high dimensional precision and consistent cutting performance.

Adjustments to cutting load, spindle rotational speed, or machine operation can all be performed through the central control system without interrupting the integrated operating cycle. Upon completion of the machining process, the operator gradually reduces the spindle speed and issues the stop command. The inverter first disconnects the motor drive, after which the hydraulic power unit is shut down. Once the hydraulic pressure has been safely released and the spindle has come to a complete stop, the cutting tool is removed from the spindle collet, and the machine is prepared for the next machining operation.

The entire operational cycle has been designed to ensure simultaneous optimization of power transmission, rotational speed, torque control, operational safety, and machining precision. Consequently, operators can perform highly accurate, repeatable, and stable turning operations without the need for complicated system adjustments or extensive manual intervention.

Data analysis

Proposed Integrated System Design

The solution proposed in this study to overcome the limitations of conventional turning systems is the design and development of a fully integrated machine in which all mechanical, hydraulic, and electronic components operate as a coordinated and unified system. This integrated architecture eliminates the need for multiple independent machines, removes the scattered and unreliable interconnections characteristic of conventional systems, and establishes a stable and highly accurate control mechanism for spindle and shaft rotation.

In the proposed machine, the spindle shaft and spindle collet, gearbox, hydraulic motor, hydraulic power unit, electrical control panel, and inverter are incorporated into a single integrated structure. These components are arranged to ensure continuous interaction among mechanical power transmission, hydraulic energy, and electronic control. Such integration not only improves machining accuracy and surface quality but also provides the operator with comprehensive control over spindle speed, torque, and driving power through a centralized control system. Consequently, the need for complex and independent adjustments of multiple devices is eliminated, while operational errors resulting from poor coordination between subsystems are substantially reduced.

The principal components of the proposed machine include the spindle shaft and spindle collet, gearbox, hydraulic motor, hydraulic power unit (hydraulic power pack), hydraulic hoses and fittings, electrical control panel, and electronic control system.

The spindle shaft serves as the primary element for transmitting rotary motion, while the spindle collet securely holds the cutting tool with high positional accuracy along the rotational axis. The collet has been selected to satisfy industrial machining requirements and to accommodate a wide variety of cutting tools. It provides reliable tool clamping with minimal clearance and maximum structural rigidity. The selection of this type of collet ensures high dimensional accuracy, suppresses tool vibration, and enables the system to withstand both radial and axial loads during high-speed machining operations.

The gearbox is responsible for regulating the rotational speed generated by the hydraulic motor according to machining requirements. By adjusting the transmission ratio, it provides the appropriate combination of speed and torque required for both light-duty and heavy-duty turning operations. Incorporating the gearbox into the system reduces the mechanical load imposed on the hydraulic motor and consequently extends the service life of the entire drive system.

The hydraulic motor functions as the primary source of rotary motion within the proposed machine. It supplies the spindle with the required mechanical power by converting hydraulic pressure into rotational energy. The hydraulic motor was selected based on its high torque capacity, operational durability, and ability to provide precise control of output power. This selection also ensures full compatibility with the hydraulic power unit and satisfies the operational requirements of the proposed machine.

The hydraulic power unit (hydraulic power pack) consists of the hydraulic pump, oil reservoir, control valves, and pressure regulation system. It generates the hydraulic power required to drive the hydraulic motor. The hydraulic power unit has been designed according to the flow rate, operating pressure, and power requirements of the system, thereby providing a stable and fluctuation-free hydraulic supply. Integrating the hydraulic power unit into the overall machine architecture enhances pressure stability while reducing mechanical stress on the rotating components.

High-pressure hydraulic hoses are employed to transfer pressurized hydraulic oil from the hydraulic power unit to the hydraulic motor and subsequently return the hydraulic fluid to the reservoir. The hydraulic circuit has been designed to minimize pressure losses while maximizing power transmission efficiency. Furthermore, high-strength hydraulic fittings ensure operational safety and long-term system reliability.

The electrical control panel incorporates switches, contactors, protective devices, and command circuits, serving as the central management unit of the machine. The implementation of a comprehensive control panel provides the operator with a single, centralized interface while eliminating the need for multiple independent control systems.

The inverter enables precise spindle speed regulation and smooth acceleration and deceleration during machine operation. Through inverter control, spindle rotational speed can be accurately adjusted according to machining requirements without undesirable fluctuations. The primary purpose of incorporating the inverter is to prevent electrical and mechanical shock, improve output accuracy, and ensure complete synchronization between the hydraulic and electronic subsystems.

System Configuration and Component Arrangement

Within the proposed machine architecture, the hydraulic power unit is installed in a separate lower compartment to prevent heat transfer and vibration from affecting other machine components. The hydraulic motor is positioned adjacent to the gearbox and aligned directly with the spindle axis, thereby minimizing torque losses and maximizing power transmission efficiency.

The gearbox is directly coupled to the spindle shaft and spindle collet, eliminating mechanical backlash and significantly reducing vibration during operation. The electrical control panel is mounted on the upper or side section of the machine to provide convenient operator access to the start controls, spindle speed adjustment, and other operational commands. Electrical cables and hydraulic hoses are securely routed through dedicated channels using appropriate restraints to prevent contact with rotating components and to enhance operational safety.

System Operation and Component Interaction

The operational sequence begins with activation of the electrical control panel. The inverter first initializes the drive system by placing the motor in standby mode while supplying the electrical power required for command and control functions. Subsequently, the hydraulic power unit is activated through the control system, causing the hydraulic pump to generate high-pressure hydraulic oil.

The pressurized hydraulic fluid is delivered through high-pressure hoses to the hydraulic motor. Under hydraulic pressure, the hydraulic motor begins rotating and transmits its generated torque to the gearbox. According to the selected transmission ratio, the gearbox converts the rotational speed and torque before transferring the output directly to the spindle shaft. The rotating spindle shaft then drives the spindle collet, enabling the cutting tool to rotate with exceptional precision, stability, and concentricity.

Throughout machine operation, the operator can continuously adjust spindle speed, rotational direction, and output power using the inverter and centralized control interface. The continuous coordination among the hydraulic power system, electronic control system, and mechanical transmission components ensures vibration-free machining, high dimensional accuracy, stable cutting conditions, and minimal operator intervention.

Ultimately, the integrated architecture establishes direct and continuous interaction among all machine components, resulting in a highly stable, powerful, and precise turning system capable of meeting the demands of modern industrial machining applications.

Conclusions

The proposed integrated lathe machine, which incorporates hydraulic, mechanical, and electronic subsystems into a unified architecture, possesses a clearly defined and highly practical position across a broad range of industrial sectors. Its applicability in small-, medium-, and large-scale manufacturing environments can be readily demonstrated. Owing to its capability to generate stable rotary motion, provide precise speed and torque control, ensure efficient power transmission, and maintain rigid tool holding, the proposed machine is well suited for a wide variety of turning operations. Consequently, it effectively satisfies the machining requirements of modern manufacturing systems engaged in the processing of metallic and engineering materials.

The integrated architecture of the drive, power transmission, and control systems makes the proposed machine particularly suitable for metal fabrication workshops, automotive manufacturing, hydraulic and pneumatic equipment production, precision component manufacturing, industrial machinery construction, mold-making workshops, oil and gas industries, reverse engineering facilities, and customized manufacturing environments. Its ability to maintain stable and uniform spindle speed, even under transient loading conditions, enables reliable performance in demanding machining operations such as precision turning of shaft-type components, preparation of surfaces for precision assembly, manufacturing of rotating components, final finishing, and precision reworking of machined parts.

Because the proposed machine operates without requiring multiple independent drive units, separate tool-holding systems, or distributed power transmission mechanisms, it is especially suitable for manufacturing facilities with limited floor space or infrastructure constraints. Small and medium-sized enterprises that cannot accommodate multiple independent machines can perform a significant portion of their turning operations using this integrated system alone.

Furthermore, the machine's robust structural design and the selection of high-capacity industrial components enable continuous and long-term operation under successive production shifts, making it highly appropriate for continuous manufacturing lines. From the perspective of operational versatility, the spindle collet is capable of accommodating a wide variety of cutting tools, allowing the machine to perform light-, medium-, and heavy-duty turning operations with equal effectiveness.

Accordingly, manufacturers of industrial machinery, industrial valves, power transmission shafts, cylindrical mechanical components, and other precision-engineered products requiring high dimensional accuracy and superior surface finish can significantly benefit from the proposed system. In addition, the thermal durability of the hydraulic power unit and the stability of the hydraulic pressure enable reliable operation under harsh industrial environments and demanding working conditions.

Overall, the proposed integrated lathe machine satisfies the essential requirements for industrial implementation and offers direct practical applicability in metal machining, precision component manufacturing, industrial equipment maintenance and repair, tool and machinery production, and any industrial sector where rotary material-removal operations constitute a fundamental manufacturing process.

References

Aksoy, h. (2017). How do innovation culture, marketing innovation and product innovation affect the market performance of small and medium-sized enterprises (smes)? Technology in society, 51, 133-141

Dess, g. G., & lumpkin, g. T. (2005). The role of entrepreneurial orientation in stimulating effective corporate entrepreneurship. Academy of management perspectives, 19(1), 147-156. 19)

Ebrahiminejad, M., & Dehghani Soltani, M. (2018). The role of technological innovation capabilities in enhancing the innovation performance of knowledge-based firms: A study of companies located in the Science and Technology Park of the University of Tehran. Journal of Public Management Research, 11–41. (In Persian).

Eggert, a., hogreve, j., ulaga, w., & muenkhoff, e. (2014). Revenue and profit implications of industrial service strategies. Journal of service research, 17(1), 23-39. 20)

Fornell, c., & larcker, d. F. (1981). Evaluating structural equation models with unobservable variabl s and measurement error. Journal of marketing research, 18(1), 39-50.

Thornhill, s. (2006). Knowledge, innovation and firm performance in high- and low technology regimes. Journal of business venturing, 21(1); 687-703.