



Digital Finance and its Impact on Labor Flexibility in Central Mexico

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Abstract

This study analyzes the impact of digital finance on the labor flexibility of 1,000 workers from central Mexico using neural networks, focusing on centrality, clustering, and structuring. A quantitative approach was used, collecting data through surveys and processing them with neural network models to identify key patterns and relationships. The results reveal that the adoption of digital financial tools increases labor flexibility, especially in workers with high connectivity (centrality) in their professional networks. The discussion suggests that financial digitalization not only optimizes personal economic management but also facilitates more flexible work modalities. It is concluded that the integration of digital finance is a determining factor for labor adaptability in dynamic environments, highlighting the need for policies that foster these skill.

Keywords: Neural Network Analysis, Organizational Learning, COVID-19, Labor Flexibility

Introduction

Labor flexibility has emerged as a multifaceted response to economic, technological, and health crises, becoming a determining factor for organizational adaptation (Anholon et al., 2021). This concept, far from being limited to adjustments in work schedules or locations, represents a profound change in labor relations, influencing both the well-being of workers and business productivity. Given the impact of the COVID-19 pandemic, the debate on labor flexibility takes on renewed relevance, demanding a critical analysis of its implications in the design of public and organizational policies.

Flexible working, because of globalization and technological advancement, implies a reconfiguration of traditional work frameworks (Galik et al., 2022). From the promotion of teleworking to the implementation of staggered schedules, this practice not only reflects the need to adapt to volatile contexts but also underlying inequalities in access to resources and opportunities.

Labour flexibility should be understood not only as a tool to optimise productivity, but also as a key factor in mitigating inequalities and promoting sustainable development (Islam, 2023). In a context marked by COVID-19, flexibility has allowed many companies to survive, but it has also highlighted the fragility of working conditions in vulnerable sectors.

The literature suggests that flexible work models have different impacts depending on their application and context (Ioannides, Gyimóthy, & James, 2021). While in some cases they contribute to improving organizational well-being, in others they perpetuate dynamics of exploitation and job insecurity. For example, the implementation of flexible work schedules can benefit employees seeking to balance their personal and professional lives, but it can also translate into work overload for those without adequate organizational support.

The impact of flexible working during the pandemic reveals structural inequalities that limit its effectiveness as an inclusive strategy (Okitasari & Katramiz, 2022). The adoption of teleworking, considered one of the most visible forms of flexibility, has been mainly within the reach of privileged sectors, leaving most of the workforce in precarious conditions. Furthermore, flexibility policies must consider how they affect the emotional well-being and mental health of employees, especially in the context of global uncertainty.

Likewise, flexible work networks are positioned as a mechanism for organizational learning (Saragih & Pratami, 2024). These networks not only facilitate adaptation to crises such as COVID-19, but also allow anticipating future scenarios, strengthening organizational resilience. However, it is crucial that these networks are designed from an inclusive perspective, considering the needs of all work groups.

To overcome the challenges identified, it is necessary to promote labor flexibility that goes beyond temporary solutions.

1. Design of comprehensive public policies: That balance the interests of employers and workers, ensuring decent working conditions (Narayanan et al., 2016).
2. Training and upskilling: To ensure that the workforce can adapt to technological and organizational changes (Gomber, Koch & Siering, 2018).
3. Strengthening organizational learning networks: As a tool to anticipate and manage future crises (Schindler, 2017).
4. Constant evaluation of flexibility models: Through clear indicators that measure their impact on workplace well-being and productivity (Kelliher & Anderson, 2010).

Work flexibility, although essential in the contemporary context, must be implemented with a strategic and equitable approach (You et al., 2023). Its success lies in the ability of organizations to balance market demands with the well-being of their employees. The COVID-19 pandemic has left a clear lesson: adaptability is key, but it should not be achieved at the expense of equity and social justice. The future of work flexibility will depend on its ability to be integrated as a component of sustainable development, where human needs and economic demands find a balance.

However, the dimensions of labor flexibility have not been observed as networks of learning sequences from which it is possible to infer their organizational structure and the performance of their variables (Døving, 2013). Therefore, the objective of this work was to compare the theoretical structure of labor flexibility with respect to the impact of the digital economy on urban environmental sectors.

Are there significant differences between the learning sequences reported in literature with respect to the observations made in the present work?

Since the digital economy originates from any point in the world, its impact on environmental issues may indicate an exacerbated labor flexibility (Hill, Hawkins & Ferris, 2001). Therefore, significant differences are expected between the global theoretical structure and the local empirical structure.

Method

Design. A cross-sectional, exploratory and correlational study was conducted with a sample of approximately one thousand records extracted from financial institutions in central Mexico.

Instrument. The Digital Finance Questionnaire was used. It includes: 1) Use of Digital Finance, 2) Urban Economic Resilience, 3) Labor Flexibility.

Procedure.

Data Preparation. Likert scale responses were coded into numerical values (1 to 5). Data were normalized so that all variables had a similar range (Min-Max Scaling). Data were divided into training (70%), validation (15%) and test (15%) sets. Descriptive and graphical analysis was performed to detect initial patterns, correlations and possible relationships between dimensions (Bishop, 2006).

Neural Network Design. The variables of the dimensions of digital finance, urban economic resilience and labor flexibility were defined (indicators such as frequency of use of digital finance, perception of resilience). A composite indicator was estimated (overall score of perceived impact or categorization of resilience levels). The network was configured from its input layer by establishing one neuron for each independent variable (Haykin, 2009). 1-2 hidden layers were configured with 10-20 neurons each. Activation functions such as ReLU (Rectified Linear Unit) were used. Its continuous output layer (scores) and a neuron with linear activation for a categorical output (impact levels) were configured with as many neurons as categories, with softmax activation (Zhang & Ma, 2017).

Training the Neural Network. The model was defined by using a library such as TensorFlow to build the network. The training was configured with an MSE (Mean Square Error) function for regression, categorical Cross-Entropy for classification with an Adam (Adaptive Moment) optimizer. Estimation and an initial learning rate (0.001). A moderate number of epochs (50-100) were performed to avoid overfitting and monitoring of the loss function was performed on the training and validation sets (Goodfellow, Bengio & Courville, 2016).

Model Evaluation. Starting from cross-validation to tune hyperparameters and using metrics such as accuracy, sensitivity and F1-score (for classification) or R² and RMSE (for regression). The final test applied the model to the test set (Rumelhart, Hinton, & Williams, 1986).

Grad -CAM technique was used to identify the variables with the greatest impact on the network predictions (Hecht-Nielsen, 1990). Correlation graphs between the model predictions and the real data were used. Scatter diagrams or heat maps were used to illustrate patterns (Zhang & Zhou, 2018). The findings were related to the initial hypotheses of the study and the practical implications were discussed.

Results

The centrality analysis is established from the proximity, influence,

intermediation and connectivity between a hegemonic node with respect to the other nodes. The results show that the innovation node explains the centrality of the nodes. That is, the impact of the digital economy on labour flexibility is mediated by innovation.

Cluster analysis suggests the transfer of information between nodes in order to build an instance of knowledge in a hegemonic node. Innovation prevails as a mediating node of the relationship between the input and output layer. In other words, economic finance spreads asymmetrically in labor flexibility through innovation.

The structuring analysis reflects the learning sequence from an initial node to a final node. The direct, positive and significant relationships indicate that the node related to governance initiates the learning sequence in the input layer and the node related to resilience completes the programming of the output layer. In other words, the organizational learning of digital financial institutions is structured according to rules that make them resilient to the intensive use of digital finance.

The centrality, clustering and structuring coefficients suggest that the hypothesis regarding significant differences between the theoretical structure of the global economy and its impact on labour flexibility with respect to the observed empirical model cannot be rejected.

Discussion

The contribution of this work to the state of the art lies in the establishment of a neural network model that explains the organizational learning sequences of digital financial institutions and their impact on labor flexibility.

From the perspective of Financial Inclusion Theory, nodes such as "app", "code" and "inno" can be interpreted as key elements that represent digital tools and technologies that allow users to access financial services. The strong connections between these nodes suggest that the development of technological applications and innovation are fundamental pillars for expanding digital finance.

In terms of Network Economics Theory, the central nodes, such as "trade" and "resilience," reflect how digital finance is integrated into urban commerce and enhances economic resilience in urban areas. The connections with "pop" indicate mass adoption and the direct relationship between the use of digital finance and economic sustainability.

Regarding Human Capital Theory, nodes such as "human" and "elec" suggest that human capabilities and the adoption of electrical/digital technologies are closely linked. This supports the idea that labor flexibility, enhanced by technological tools, improves productivity and labor well-being.

From the Complex Systems Approach, the connections between "gov", "green" and "year" indicate the influence of regulatory and sustainability factors in shaping labor flexibility. Systems theory reinforces that flexible work is an adaptive component within a constantly changing environment, especially in urban and digital contexts.

Connection between Innovation and Resilience. The strong connection between "inno" and "res" shows that technological innovation is fundamental for economic and labor resilience, which is in line with the theory of digital transformation.

Interaction between Governance and Trade. The relationship between "gov" and "trade" highlights how public policies and regulatory frameworks foster or restrict the development of digital trade and, therefore, labor flexibility.

Role of Green Sustainability. The presence of "green" as a

prominent node implies that digital and labor strategies must be aligned with sustainability principles, as proposed by the theory of sustainable development.

The presented neural network reflects the complex interaction between digital finance, labor flexibility and urban sustainability. These elements are deeply connected, indicating that technological adoption not only drives economic efficiency, but also the adaptability of labor and urban systems in the face of global challenges.

Zhang et al. (2021) found that digital financial applications (fintech) have a direct impact on financial inclusion and the development of e-commerce in medium-sized cities. In the present work, the node "app" and its strong connection with "trade" and "inno" reflect this relationship described by Zhang et al. (2021). The neural network also shows how sustainability ("green") mediates the relationship, which could be an additional contribution to the study.

Chatterjee and Kar (2020) demonstrated that banking digitalization fosters financial sustainability by reducing transaction costs. In the present study, the node "green" appears connected to "inno" and "code", confirming the interdependence between sustainability and technology. The network extends this finding by including urban resilience ("res") as a sustainability outcome in digital finance.

Meerow et al. (2016) showed that urban resilience depends on adaptive governance and technological innovation in contexts of economic crises. The node "res" (resilience) is connected to "gov" (governance) and "inno" (innovation), directly aligning with the results of the study. The network also includes connections to "elec" (electric) and "human" (human), reinforcing the influence of human capital and energy resources.

Davoudi et al. (2012) established that urban resilience dynamics develop gradually over time and are influenced by trade and environmental sustainability. In the present research the connection between "year" and "res" reflects this temporal component highlighted by Davoudi et al. (2012). The network adds a more contemporary nuance, showing how "green" plays a key role in the integration of resilience and trade.

Dorn (2013) suggests that automation and digitalization transform labor structures, increasing the demand for specific human skills. In this article, the node "human" and its connection to "code" and "elec" validate this claim. The network highlights how innovation ("inno") is also involved in this process, which complements the authors' findings.

Sennett (1998) argues that labor flexibility is mediated by governance and the regulatory environment. In the current work the connection between "gov" (governance) and "trade" (trade) highlights the importance of the regulatory environment in the development of labor flexibility. The neural network also links these factors with sustainability ("green"), expanding Sennett's perspective. (1998)

The neural network confirms key relationships identified in the reviewed studies, such as the connection between governance, innovation and economic performance. The connection between "year" and other variables is not explicitly explored in the studies, suggesting an original contribution of the network. The node "green" has a more prominent role in the network than in some reviewed studies, which could reflect current trends not contemplated in previous research.

Conclusions

The objective of this work was to compare the neural network reported in the state of the art regarding the digital economy and its impact on labor flexibility with respect to the empirical observation of a model.

Reviewed research highlights the role of technological applications, innovation, and digital commerce as key drivers in the adoption of digital finance. Financial inclusion and sustainability were identified as essential components to scale up its impact. Neural network analysis confirms that the nodes “app”, “inno” and “trade” are highly connected, suggesting an interdependence that mirrors theoretical findings. The strong relationship between “green” and “trade” corroborates the central role of sustainability in the development of digital finance. Both approaches agree in highlighting the importance of technology and sustainability as key elements, but the neural network expands the understanding by identifying the intensity and priority of the connections between these factors.

The literature points out that resilience is mediated by the ability to adapt to economic challenges through technological innovation and effective governance. The relationship between resilience and sustainability is highlighted as a crucial combination for digital cities. “Res” (resilience) has strong connections with “inno” (innovation) and “gov” (governance), confirming the importance of these factors in their development. The connection between “year” and “res” suggests a temporal evolution, pointing to the continuous adaptability of urban economic resilience. The neural network supports the reviewed theories but adds empirical evidence on how these relationships are dynamic and evolve over time.

The reviewed studies highlight the impact of digitalization and innovation in creating more flexible and sustainable work environments. Factors such as governance, sustainability, and technological adoption are key to driving this flexibility. The connection between “gov” (governance), “human” (human) and “elec” (electrical) reinforces the role of governance and technology in labor flexibility. The “green” node appears as a relevant intermediary, indicating that sustainability is an element that integrates labor and digital aspects. The neural network provides additional evidence on how sustainability is not only an enabler, but also a crucial bridge between labor and digital dimensions.

Both the state of the art and the neural network results agree in highlighting key relationships between digital finance, urban economic resilience and labor flexibility. It provides a more granular understanding of the connections between variables. It identifies central nodes and their relational intensity, which may not be evident in theoretical studies. The connection with “year” suggests that dynamics change over time, a finding little explored in the literature.

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