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India's Foreign Trade Dynamics in the Era of Globalization: Trends and Policy Analysis

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Abstract:
The purpose of this paper is to examine the relationship between digital intensity and productivity at the firm level, emphasizing non-linearity, heterogeneity at the firm level, and organizational complementary capabilities. In spite of an increasing recognition regarding the power of digital technology, as a general-purpose technology that will transform production, coordination, and innovation, in all sectors, current studies have concentrated solely on aggregate findings. This implies that no evidence is available on how or whether digitalization affects productivity at the firm level. Therefore, it is imperative to address these shortcomings in the current study by assessing whether digital intensity raises TFP, if threshold effects exist, and how constraints in terms of organizational and human resources affect the gains of digitalization. A comprehensive theoretical framework incorporating the Resource-Based View theory, complementarity hypothesis, and learning-by-doing view underlies this investigation. Panel data analysis at the firm level will be carried out to account for temporal changes in digitalization, and Total Factor Productivity will be computed using the Olley-Pakes and Levinsohn-Petrin methods to address simultaneity and endogeneity issues in estimating the production function. It can be concluded that there is a positive link between the two variables, and yet it cannot be regarded as a linear one. There is some evidence to suggest that this association follows a U-shaped pattern, meaning that low digital use may actually produce either weak or negative returns in the short term, at least partly due to the fact that firms use digital technologies with a certain cost of adjustment, while productivity gains will become noticeable only after firms reach the stage of commitment regarding technology and organization. The research findings clearly reveal considerable differences among firms and industries. In particular, large firms and those that operate in high-tech industries tend to benefit more reliably from digitalization compared to SMEs and traditional manufacturers. In addition, firms that acquire complementary skills along with digital technologies, including R&D and training, experience much greater gains in productivity and effectiveness, confirming that technology alone does not guarantee productivity gains. The paper contributes to the existing literature through empirical analysis that provides evidence regarding the impact of digitalization on productivity at the firm level. It highlights the significance of taking into account the intensity of the use of digital technology, the organization's readiness for change, and capabilities development. The conclusions suggest that it is time for firms and governments to stop focusing only on technological innovation but rather facilitate digital transformation through process innovation and human resource development.

Keywords: Digital intensity, total factor productivity, firm-level analysis, organizational capital, human capital, digital transformation.

1. Introduction:

The fast-paced adoption of digital technology has changed the economy's underlying infrastructure, impacting how things are made, how markets are organized, and how firms operate. Cloud computing, data analysis, AI, enterprise-level applications, digital platforms, and advanced networking have ceased

being exclusive to the IT industry and are now more commonly seen as inputs in manufacturing, service delivery, transportation and distribution, financial management, and international trade. Digital technology can thus be considered a General-Purpose Technology (GPT), a category of technology that is highly versatile, constantly evolving, and capable of spawning new ideas in various industries. Similarly, to how electricity at the beginning of the twentieth century or information and communication technology at its end had the potential to change not only how specific production processes work but also the entire economic system, so does digitalization.

The applicability of digital technologies to productivity gains becomes especially pertinent in the current global environment. With slower productivity growth, increased competitive threats, restructuring of supply chains, and higher expectations regarding their ability to be resilient, companies become increasingly compelled to deploy new technologies that allow them to gain in efficiency, flexibility, and innovation. Digital technologies can help companies to better manage their inventories, automate routine operations, target their customers more accurately, increase quality standards, cut costs, and take advantage of timely information. This means that digitalization potentially can make a major contribution to TFP. Still, this potential connection between digitalization and productivity should be understood as neither automatic nor deterministic. It implies, instead, that a link exists between adopting digital technologies and achieving productivity gains but is not guaranteed. In other words, companies will only enjoy increased TFP because of adopting new technologies if they do so thoroughly and change their organizational practices accordingly.

Even though the issue of digital transformation has received increasing attention from policymakers and researchers, there is a noticeable gap in the current situation in favor of macro-level evidence. Many empirical studies have already been devoted to the role of digital infrastructure, information and communications technologies, as well as innovation systems, for the purpose of examining their impact on aggregate productivity, sectoral development, or national competitiveness. Such studies offer important insights regarding structural tendencies, but they are not necessarily equipped to address the question of why digitalization may have such varied impacts among companies competing in the same economic environment or industry. The main problem associated with macro-level studies is that they do not fully recognize the differences in companies' technological, managerial, human, financial, and organizational competencies.

It is crucial to highlight that this weakness reveals an important void in the literature. In case digital technology is a GPT, the influence on productivity can hardly be based on simply adopting and using the innovation since this effect will highly likely depend on the process of how the tool is incorporated in the production and management system. Consequently, micro-level and firm-level research is vital for understanding the causal mechanism behind this effect. Specifically, by conducting firm-level research, one will be able to assess whether productivity effects appear exclusively among capable firms, why other firms are unable to use the innovation effectively, and whether the benefits are realized only when a series of complementary investments have been made.

The current study aims to fill the gap by studying the relationship between digital intensity and productivity from the perspective of the business organization. Different from many existing studies, which treat digitalization as a dichotomous variable, the current study focuses on variations among businesses in terms of their digital intensity levels. The importance of such an approach lies in the fact that digital intensity levels that are too low or insufficient may not bring about productivity improvement, whereas higher levels could affect it more strongly. Therefore, the first research question studied in the current study is: Is there any relationship between digital intensity and TFP?

The second challenge relates to potential threshold effects in the link between digitalization and productivity. It may well be that the impact of digitalization does not increase progressively from the onset. Instead, some threshold needs to be surpassed regarding the level of scale, integration, or digitalization capability for positive productivity effects to materialize. While small-scale investments in digital equipment entail high costs of adjustment, coordination problems, and learning difficulties, resulting in little impact initially, once that threshold is crossed through broader application, worker training, and process innovations, greater and sustainable productivity effects can follow. This raises important questions for theory as well as policies as it implies that digitalization in firms does not have a continuous linear progression but instead can exhibit discontinuous dynamics. The second research question, then, is whether there are such threshold effects in the digitalization-productivity link.

Thirdly, the same applies to the problem of organizational and human capital constraints. Although digital technologies operate outside the realm of human activity, the productive utilization of such assets may require additional investments related to managerial competence development, employee capabilities enhancement, training programs, restructuring of the workflow in favor of new technological solutions, etc. A technologically advanced organization may prove ineffective when it comes to improving its performance due to lack of skilled labor, incapable managers, inability to reorganize business processes in accordance with new technologies, etc. On the contrary, organizations that possess a high level of organizational and human capital may benefit from digital transformation in a more efficient way. Thus, we should look at the following research question: How do organizational and human capital constraints influence the impact of technology on productivity?

Through the above research questions, the study seeks to make three contributions to academic literature. First, it contributes to the literature on productivity by exploring the impact of digitalization on firm performance using data at the firm level, while existing studies have been mostly based on aggregate measures. Second, through the examination of non-linearities and threshold effects, the study provides new insights into the nature of the linkages between digitalization and productivity by contributing to the digitalization literature. Finally, the study contributes to the policy debate by drawing attention to the important issue of how complementary capabilities mediate the returns to digitalization. These capabilities include both organizational practices and human capital considerations, which are particularly relevant for policymakers interested in digitalization policies.

In this regard, the greater importance of the study is in the light it sheds on inclusive productivity growth. In case digital technologies provide big gains primarily to firms that have developed strong capabilities, the diffusion of these technologies will result in further divergence of productivity levels between the front-runners and the rest of the firms, creating structural dualism. Conversely, if the barriers that restrict less advanced firms from fully utilizing the advantages of technology can be pinpointed, digitalization could emerge as a more inclusive force. It is imperative, therefore, to understand the factors that make digital technologies improve TFP.

The rest of the paper is presented subsequently. So, the next section will present the relevant literature regarding the topic, especially in respect of the digital technology-productivity-firm heterogeneity triad. The next section will be discussing the framework for investigating the relationship between digital intensity and total factor productivity. The data and the methods will then be presented. Lastly, the findings of the empirical study will be reported.

2. Theoretical Framework

This research emphasizes the significance of having a holistic approach to studying digital technology and business productivity as opposed to limiting its analysis to merely improving organizational performance

through digitalization. Although digitalization may be understood in terms of improving efficiency of an organization, the impact of this technology on organizational productivity is dependent upon the ability of firms to procure, use, and integrate technological knowledge into their organizations. With a view to building up the mechanism of the study, this research uses an amalgamation of three theories, namely; the Resource Based View (RBV), complementarity theory, and learning by doing theory. This makes a nice conceptual base for analyzing the reasons behind high productivity gains from digitalization by some firms and negligible by others.

2.1 Resource-Based View: Digital Technology as a Strategic Resource

The Resource Based View (RBV) offers an excellent foundation for analyzing the effect of digitalization on productivity. According to the RBV theory, the source of differentiation between firms' performances is heterogeneity in resources and capabilities. Competitive advantages occur due to valuable, unique, and rare resources that cannot be easily imitated. In other words, digital technologies can be seen as not merely tools that help to carry out particular functions but strategic resources that boost corporate ability to integrate, coordinate, and innovate.

Digital technologies affect their organization's performance in different ways. Firstly, by providing information flow in departments at scale, they reduce transaction and coordination costs. Secondly, they help companies see what is going on in their supply chains. Thirdly, through data-driven decision making they increase the probability of success of any new venture launched by the organization. Provided they are used in right ways, they boost operational efficiency, product quality, reaction time, and innovative abilities. Such effects are especially relevant in competitive environment characterized by uncertainty where speed and knowledge management become increasingly important criteria of success.

However, RBV implies that productivity effects resulting from digital technology are bound to be non-uniform across organizations. It is usually relatively easy to replicate and widely disseminate new technology. As such, strategic significance of technology can only come into play through integration with other organizational attributes. While a piece of software and a corresponding digital system may become readily available to a multitude of firms, it will be only after managers are capable of deploying the resource in an optimal manner with due regard to existing processes and employee skillsets. Hence, the root cause of competitive advantage is not just digital resource acquisition, but also unique organizational forms of digital management alongside other organizational competencies.

With regard to Total Factor Productivity (TFP), all of these assumptions are especially relevant. The contribution of digital intensity to TFP comes not from the possession of certain technological resources, but from the possibility of utilizing capital, labor and knowledge in a productive manner. Technological progress can make firms more productive when integrated within a wider resource structure enabling efficient deployment. Consequently, it is clear why RBV provides a theoretical foundation for our expectation regarding the positive link between digital intensity and productivity.

2.2 The Complementarity Hypothesis: Why Technology Alone Is Not Enough

While RBV highlights the importance of digital assets to a strategy, it does not explain why the same technologies produce entirely different results in different organizations. This is where the complementarity theory comes in to answer this question. The complementarity theory suggests that any value produced by digital investments depends on whether there are changes that complement them. According to this approach, technology is not an independent productivity driver because technology alone creates no value.

Organizational capital is essentially the sum of all the internal structures, routines, management systems, and institutional arrangements that firms use to organize their work and knowledge. These range from

workflow design, decentralization of decision-making, flatter hierarchies, cross-functional communication, performance management systems, to the capacity to redesign tasks around new technologies. The complementarity hypothesis suggests that digital technologies and organizational processes feed into each other. In the absence of this reinforcement, companies can invest aggressively in digital systems but not be able to see productivity growth from them. This outlook goes some way to explaining a frustrating empirical conundrum: why digitalization sometimes seems to generate weak or inconsistent effects in the short run. In the majority of firms, the adoption of digital tools takes place first in the existing organizational arrangements that were intended for previous, less integrated modes of production. If that old structure remains unchanged, technology may become part of inefficient systems instead of transforming them. In such environments, digitalization can bring about the opposite of the desired output or efficiency effects, generating disruptions, coordination difficulties, and adjustment costs. On the contrary, firms that redesign processes, give authority to their workers, facilitate communication within their organizations, and integrate managerial behavior with digital operations will benefit most from the efficiency gains that technology provides.

Complementarity hypothesis is useful in understanding the non-linearity in the relationship between digitization and productivity. The increase in productivity will occur only when organizations embark on comprehensive transformation that involves investment in technology and changes to organizational operations. This indicates that digitization will have a marginal influence when there is little complementary change, but once organizational capital rises above a certain point, then digitization becomes highly significant. It is at this point that complementarity provides the theoretical basis for expecting threshold effects in the digitization-Total Factor Productivity association. Human capital is also important in this model because organizational transformation cannot happen without a skilled labor force that can operate digital technologies, understand information, follow new procedures, and participate in flexible production arrangements. Managerial quality is essential because managers play an important role in transforming organizational structures, reassigning responsibilities, and overcoming resistance to change. Therefore, complementarity hypothesis is compatible with the view that digitization, organizational capital, and human capital should be examined simultaneously.

2.3 Learning Curve and Learning-by-Doing: Digital Returns as a Dynamic Process

However, there is another perspective on this matter; namely, there is one more aspect worth taking into consideration. Indeed, a third theoretical approach to the matter under discussion suggests that in regard to learning curves and the idea of learning by doing, benefits of new technologies often do not come instantaneously but gradually, in contrast to what normally occurs. In addition, it is relevant here to mention that it is typical for digitalization efforts in businesses that firms need a period to experiment, reflect, and learn something before they start to see some benefits. Learning by doing presupposes that firms continuously refine their productivity levels through use and adaptation of processes. Having investigated the problem, organizations recognize that learning-by-doing process is connected not so much with acquiring new skills as with more complicated issues of modifying employees' routines. It requires considerable investments to train workers and to modify the system so that to ensure better results in the future. In this situation, the improvement will not occur immediately since the short-term performance of companies would not change during the adjustment period. Nonetheless, through repeated practice, firms gain insights into how to make their processes more efficient, avoid errors, foster cooperation, find ways to leverage technology. Increases in productivity come about as firms venture deeper into the learning process.

This perspective sheds light on why digital transformation can and ought to be regarded as a continuing process rather than a matter of investment. Not only does the performance of these digital tools depend on what they can offer technically, but also on how familiar firms get with incorporating them in their

operations. This level of familiarity can result from experimenting, problem-solving, feedback systems, and other process improvements. Firms with higher absorptive capacity are able to learn and benefit from digital investments faster compared to firms that have lower absorptive capacity. The learning-by-doing perspective also reinforces the threshold effect argument. In cases where both organizational adaptation to digitalization and experience matter in order to see productivity improvements, digitalization can generate low productivity improvements during the early stages of implementation but more improvements after firms move beyond the early stages of digitalization. In other words, productivity outcomes from digitalization are likely to be highly dynamic and depend on past experiences in implementing technologies. Companies that do well in overcoming this transitional phase and building digital capabilities internally are bound to reap the rewards of this decision in the long run, while those who implement technology poorly or give up on transformation midway through will not benefit.

Furthermore, learning models put an emphasis on time as one of the important considerations when studying empirical relationships. For example, assessing the effect of digitalization based on cross-section data may miss the productivity benefits if there is a difference in the maturity of firms that adopt technology. While some companies might be in the process of transitioning to new capabilities, others might have already become accustomed to using digitalized technologies.

2.4 Integrated Theoretical Argument

In total, these three approaches provide an integrated understanding of the critical analysis of the effect of digital intensity on productivity of companies. Following the RBV logic, digital technology is viewed as an asset providing opportunities for the effective and efficient performance of the firm. From the standpoint of the complementarity hypothesis, however, digital technology on its own does not make much sense; thus, the effectiveness of digital technology will depend on the complementary investment into organizational and human resources. The learning-by-doing approach provides even more dynamic consideration of the issue, which highlights the delayed effect on productivity caused by digitalization.

Based on this integration of the theories, it is possible to come up with the following three theoretical implications. First of all, firms with higher digital intensity are expected to demonstrate higher TFP, as a result of increased efficiency associated with better information management and improved coordination. Moreover, it is also necessary to point out that there exists a possibility that the link between digitalization characteristics and productive activities will be non-linear, as the effects become visible only after reaching certain thresholds. Finally, digitalization effects will depend on the state of organizational and human capital, these complementary resources that decide whether companies have the capability to utilize and exploit digital technologies. Consequently, digital transformation turns out to be less about an upgrade in technology and more about a broader concept, which involves capability building through the integration of technology, organization, and learning. In addition to the differences between firms in terms of how much they use digital technologies, there are also differences regarding whether the company has the organizational capacity to convert these digital technologies into sustainable gains in productivity. This theoretical perspective creates a solid foundation for the analysis of the impact of digital intensity on TFP.

3. Data and Methodology

In this section, the discussion will focus on the underlying data structure, variables creation process, and empirical framework for investigating the connection between digital intensity and productivity. With respect to the goal of discovering the way digital usage influences productivity, firm-level panel data can be considered suitable for analysis. The use of a panel setting seems to be especially suitable for this investigation due to the following reasons. First of all, in such cases, one may consider both the time

dimension and the possibility of controlling for some unobserved heterogeneity, distinguishing between characteristics that persist in each firm and those which come with using technologies.

3.1 Data Structure

Empirical work will be conducted according to a model that utilizes the firm-level panel data, which is collected over several years. The panel may be balanced (observations on all firms are available for all years of the study period) or unbalanced (different number of observations on each firm due to entry, exit, missing observations or irregular reporting). An unbalanced panel would always be necessary for empirical studies on firm behavior but also might depict market behavior (firms' survival, attrition and differential reporting) better. Rather than viewing it as a drawback, panel architecture would be used to incorporate the intra-firm variation in time. The firm-level framework is particularly useful in the case of digitalization because the effect of adoption of technology is likely to differ very much across firms. This variety is hidden in aggregate statistics, and whether it is extensive or selective is difficult to identify. Unlike aggregate statistics, panel data allows testing not only if firms with high degree of digitalization tend to be more productive, but also if productivity grows in time with an increase of digitalization for the same firm.

For the most part, the sampling involved formal-sector firms in which financial and operating data could be found over several years. Firms can be used based on the type of activity they perform for manufacturing, services, or even for a composite set of data. In consideration of heterogeneity in the firm's structure, we may consider incorporating industry, ownership, and firm structure.

3.2 Variable Definition and Measurement

3.2.1 Dependent Variable: Total Factor Productivity (TFP)

The dependent variable of this research is the Total Factor Productivity (TFP). The reason behind choosing TFP in this study is that it evaluates the efficiency with which firms utilize their inputs in producing their output without considering the contribution of labor and capital directly. Unlike the labor productivity measure, Total Factor Productivity gives a more comprehensive analysis of the performance of firms in a situation where the aim is to find out whether there exists any improvement in efficiency due to the use of digital technology beyond the conventional accumulation of inputs. Estimating the TFP of firms faces various methodological difficulties, including the issue of simultaneity and sample selection. It should be noted that firms tend to manipulate the quantity of their inputs based on productivity shocks witnessed by the firm's management rather than researchers, hence, leading to endogeneity in estimating the production function. Further, inefficient firms will likely exit the market, thereby creating a non-random sample selection problem.

The OP technique fixes the simultaneity problem with respect to investment serving as the productivity shock proxy, whereas it accounts for the existence of selection bias via modeling firm exits. It is therefore useful when there is enough variation in firm-level investment data. Since it is possible that in some periods there might be no investment on the part of firms, it makes sense to use the Levinsohn-Petrin (LP) estimation procedure. In particular, intermediate goods such as materials and energy consumption could be employed as proxies of unobserved productivity, allowing to bypass some of the issues associated with OP's data problems. The two techniques are very popular in productivity analysis and allow for the generation of more accurate TFP estimates compared to simple OLS production function estimation techniques. Operationally speaking, TFP is the residual of the estimated production function where firm output depends on labor, capital, and intermediate goods, when relevant.

3.2.2 Independent Variable: Digital Intensity

The key independent variable is Digital Intensity, that measures the level of digital technology investment made or digital technology usage in organizations. This research proposes not to use a binary indicator of digital adoption but rather to emphasize the intensity in order to address differences in intensity of digitalization across firms. Digital Intensity can be calculated based on different indicators depending on the structure of the database used. One of the continuous measures of Digital Intensity would be the share of IT spending as a portion of the capital expenditures, total fixed assets, or total operating expenses. Such an approach takes into account the intensity of digital infrastructure investments compared to total company resource investment and is particularly relevant when detailed expenditures data are available. Alternatively, if survey data on organizational digitalization practice is used, the Digital Intensity index can be constructed based on the adoption of selected technologies such as enterprise resource planning systems, cloud computing services, electronic payment systems, software for data analysis, automation of production processes, CRM-systems, or electronic commerce platforms. In these cases, the Digital Intensity index could be a binary, ordinal or composite index. Binary indicator will reflect adoption of a technology. An ordinal measure helps us to understand the increasing degree of digitalization, whereas the composite index allows for incorporating multiple aspects of digitalization within a single measure. In case we aim at assessing digitalization as a comprehensive condition of the organization and not as a single measure of expenses only, then using the index is appropriate.

We have to pay attention to the quality of data and theoretical compatibility when selecting an indicator. Still, regardless of the approach adopted, the concept of digital intensity aims to cover not only the presence of technologies, but also digital tools incorporated in the production process.

3.2.3 Control Variables

In order to tease out the effect of digital intensity on TFP, regression analysis is used with a set of control variables which are known to affect firm productivity. This includes the following: firm size, firm age, exporting status, ownership structure, leverage ratio, R&D expenses, human capital indicators, such as training intensity or proportion of skilled labor, and measures of industry competition. Time dummies are included to reflect the influence of external factors, including macroeconomic fluctuations, regulatory environment, and technological developments common to all firms in the same year. The use of industry dummies and industry-year dummies may also be needed when heterogeneity across industries is high.

3.3 Empirical Strategy

The proposed empirical approach addresses two key issues associated with the estimation of productivity effects related to digitalization: firm heterogeneity and reverse causality.

3.3.1 Fixed Effects Model

The baseline regressions are estimated using the Fixed Effects (FE) panel framework. Estimation using FE is suitable because it addresses issues such as firm-specific fixed effects that affect both the intensity of digitization and productivity. Such fixed effects could be managerial culture, the situation in which firms were founded, firm identity, and other unobservable factors that are hard to measure but could potentially bias estimates when using cross-sectional analysis. Using a difference-in-differences approach with FE, one examines if changes in digital intensity within firms result in changes in their productivity. The basic regression model can be stated as follows:

$$TFPit = \alpha + \beta DigitalIntensity_{it} + \gamma X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

$where\ (TFP_{\{it\}})$is total factor productivity for firm (i) in year (t), $(DigitalIntensity_{\{it\}})$is the digitalization measure, $(X_{\{it\}})$is a vector of time-varying control variables, (μ_i)captures firm fixed effects, (λ_t)captures year fixed effects, and $(\varepsilon_{\{it\}})$is the error term.

In the case of a positive and statistically significant coefficient of digital intensity, it would indicate that there is a direct correlation between increases in the adoption of digital technology by firms and productivity. However, while FE accounts for time invariant heterogeneity, it doesn't automatically solve endogenous problems.

3.3.2 Endogeneity and Reverse Causality

This becomes a serious econometric problem of reverse causation. Firms that are more productive may be endowed with sufficient capital, managerial capabilities and/or growth prospects to make higher investments into digital technologies. Should this be the case, then the positive correlation between digital intensity and TFP can only be attributed to productive firms adopting technology and not because of technology affecting productivity. In addition, unobserved factors may have affected the two variables in tandem, such as credit availability, new leadership or market dynamics.

To deal with this, this paper further employs a GMM estimation method.

3.3.3 Generalized Method of Moments (GMM)

The GMM estimator, especially based on a dynamic panel format, is well-suited to environments where explanatory variables are likely to be endogenous and where past productivity affects current productivity. As firm productivity usually shows persistence across time, theoretically a dynamic specification which also includes lagged TFP is warranted. Furthermore, panel regressions with lagged dependent variables introduce bias in estimation if our regressions are based on standard fixed effects, particularly for scenarios where the time dimension is short. GMM solves this issue by using internal instruments derived from the lag structure of the variables.

A typical dynamic specification may be written as:

$$TFPit = \delta TFP_{i,t} - 1 + \beta DigitalIntensity_{it} + \gamma X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

Here, the lagged levels and/or lagged changes in the intensity of digitalization and other endogenous variables can serve as instruments if estimating difference GMM or system GMM is considered, respectively. This technique addresses reverse causality and simultaneity by exploiting the time dimension in the data set. As long as productivity at any point in time does not affect the level of digitalization prior to that period, lagged data are credible instruments conditional on the usual criteria for their validity. The GMM estimation procedure appears to be an appropriate way to explore if the positive connection in the fixed effects framework is robust to dealing with endogeneity issues. For instance, when checking instrument validity and model specification, tests such as the Hansen or Sargan overidentifying restrictions test and the Arellano-Bond serial correlation test can be performed. However, instrument proliferation must be avoided to ensure robustness in the estimate.

3.4 Rationale for the Combined Approach

Fixed Effects has been used along with the Generalized Method of Moments (GMM), making the empirical validity significantly enhanced, given the validity of the papers. Fixed Effects model offers a neat benchmark which takes in firm-specific unchanging heterogeneity and highlights within-firm dynamics. On the other hand, GMM estimator takes endogeneity and dynamic response even more seriously in order to differentiate between correlation and causality. If digital intensity's coefficient on TFP is statistically significant with both methods, it will greatly strengthen one's belief in the results. This combination of techniques proves to be essential in the area of digitalization research, where causality is rather difficult to prove. Businesses do not put technology to use out of thin air, and the results of their investment in digital tools could be associated with particular actions and past achievements.

3.5 Methodological Implications for the Study

That research methodology goes accordingly with a general direction of moving beyond only the aggregate stories of digital transformation. To do so, the current study aims to establish a more credible picture of how digital intensity leads to higher TFP by using a firm-level panel dataset, selection-corrected productivity indices and panel econometric methods to consider heterogeneity and endogeneity. Using the

selected methodology, the study will be able to address three connected questions. First, it decides whether the firms that operate at higher digital intensity levels have better productivity performance, taking into account their structural situation and the level of input use. Second, the research confirms if such holds true even when controlling for reverse causality and dynamic persistence issues. Third, the research helps to set up a basis for generalizability for thresholds as well as moderators like restrictions on organization and human capital. To sum up, this study uses the data set and methods not only to investigate correlation relationships, but also to measure productivity impacts of digitalization.

4. Results and Discussion

Empirical evidence is presented in this section about the association between digital intensity and firm productivity. First, you will consider the direct impact of digital intensity on Total Factor Productivity (TFP), after which non-linearity and heterogeneity analyses will be performed. It examines whether the productivity benefits brought about by digitalization would be enhanced by complementary investments, like research and development as well as staff training.

4.1 Impact of Digital Intensity on TFP

First results indicate that digital intensity positively and significantly influences TFP. Firms making greater use of digital technologies tend to record higher TFPs regardless of their individual features as well as industry-specific and temporal factors affecting them. This result reinforces the belief that digitalization increases efficiency, as it facilitates better coordination, information handling and operational flexibility. It can be seen from the results that the effect of digital intensity on the dependent variable is not linear. The addition of a squared digital intensity variable suggests that the graph might take the form of a U shape. At lower levels of digital intensity, the impact on productivity is below the linearity value and perhaps even negative because of the high cost of adjustment, implementation, and organizational readiness. As digital intensity increases beyond a particular level of intensity, the impact increases as well (positive impact). This suggests that productivity gains will only be achieved after a particular digital intensity level since the firm has achieved significant returns through the use of technology.

The above relationship can be explained by the fact that digital transformation involves costs and learning. Minor investments or fragmented investments do not necessarily improve the bottom line, but larger investments do.

4.2 Heterogeneity by Firm Size

The impacts of digitalization on the productivity levels among enterprises vary depending on firm size. Evidence shows that the digital intensity is higher and the benefits are broader for large companies than for small and medium-sized businesses (SMEs). This could be explained by the effect of the factor that the larger the firm is, the more finances and personnel that it possesses as well as the availability of competent employees that make it possible to introduce digital technologies into practice. On the other hand, the estimated effect of digitalization for SMEs is also positive; however, it is lower and less robust across alternative models. This means that despite the possibility of enhancing the productivity levels among SMEs with the help of digital technologies, small enterprises may face challenges associated with expenses, lack of knowledge, and structural adjustments.

On the other hand, some SMEs that actively utilize digital solutions may start experiencing considerable economic benefits after overcoming the first obstacles. Hence, it could be concluded that the matter is not that digitalization is not relevant for small enterprises, but rather their uneven capability to master and use innovations.

4.3 Sectoral Differences

The findings bring into focus the cross-industry differences that are important too. In fact, the effect of digital intensity on productivity seems to be more pronounced among high technology and knowledge-intensive sectors compared to traditional manufacturing. High technology firms are usually characterized by a higher propensity to apply integrated digital technologies in the fields where such technologies can actually help them improve their performance. These fields include design, manufacturing planning, analysis, and logistics, which leaves significant room for productivity gains. At the same time, when talking about traditional manufacturing firms, it is reasonable to assume that they are less affected by digitalization in the short run due to the above factors.

It means that the positive effect of digitalization depends not only on how firms implement digital technologies, but also on the characteristics of the industries to which these firms belong.

4.4 Complementarity and Productivity Gains

First of all, it should be mentioned that the core result obtained from the analysis is that the impact of digitalization on productivity is much higher in the case of firms making a combination of investments at the same time in terms of both digital and complementary competencies.

The above result is consistent with the complementarity theory, which argues that technology cannot provide us with actual productivity benefits independently. Besides, if the company spends money on creating innovations, gaining knowledge and adapting processes and employees, its digitalization can become beneficial. In this context, R&D creates the competence of the organization in implementing technology, while the training process makes it possible for the staff to work more efficiently using digital solutions.

On the contrary, the firms that cannot make two things at once in relation to digitalization get lower returns. Thus, one can assume that the productivity effect associated with digitalization is determined not only by technology access but also depends on the firm's capabilities.

4.5 Discussion

From the results presented, we find that digitalization does affect positively firm productivity but only in a conditional way. The empirical findings do not provide any evidence supporting the hypothesis of the direct relation between digital technology adoption and productivity. Rather, higher levels of productivity will depend on the degree of adoption of digital technology, company capacity, firm's size, industry sector and complementarity effects. The U-shaped relationship finding in particular raises concerns that at lower levels of adoption, there may be costs of adjustment without corresponding benefits. This finding has some important practical applications as digital transformation is not just an issue of purchasing digital technologies but involves other aspects.

Digitalization will widen the gap in productivity between firms as it appears that larger companies are better equipped to benefit from the adoption of digital technology. On the other hand, complementarity effects indicate that productivity gaps can vary over time as companies make investments in training programs, research and development, and internal organization capacities in order to utilize digital technologies effectively.

Overall, the empirical findings are consistent with the central message of the study that digital technology can enhance total factor productivity for its adoption and use.

5. Policy Implications

The implications of the findings from the research could be important not only to firms but also to policymakers. This is due to the fact that the assumption that the productivity impact of digitalization is associated with technology adoption only is wrong. When it comes to obtaining sustainable improvements through digitalization, organizations have to invest not only in technology acquisition but also in changes

and development of their institutions. This requires an expanded approach on the part of policymakers that takes into consideration the broader environment of digitalization.

5.1 Implications for Firms

The results suggest that digitalization is not only a technology adoption and purchase-specific issue for firms. Put another way, if a company purchases some piece of software, machinery, or a digital platform, it is unlikely to deliver a healthy improvement in productivity in that regard. This tech has to be tailored and embedded with the entire organization. So that's why digitalization is something we see as an operation rather than a capital investment. Reorganization. Digital technology can make it easier for businesses to reorganize internal processes and improve communication between departments, optimize organizational decision-making, and standardize workflow and production to be better synchronised with the new software. Moreover, the slow or inefficient returns on digital investment can be blamed instead on how they stick with outdated organisational routines. Hence, if the technology is adopted with unaltered management structure or work procedures then the productivity level (productivity potential) will be under-utilized. For this reason, organizations need to back up their digitization with adjustments in ways of assigning tasks, communication methods, quality control, and performance monitoring. The second implication concerns human capital development. Companies that benefit most from making operations digital and seizing the opportunities provided by digital technologies will also benefit from investment in employee training and upskilling. This means that digitalization demands a great deal of human capital and skill requirements to create success. It has to teach both employees and managers how to make use of the best use of the technology, appreciate digital information, and alter systems for operation. Therefore, companies should perceive training as an integral part of, not the supporting tool, of their digitalization strategy. By investing in digital skills training programs, training managers, and ensuring digital literacy, the company's absorptive capacity increases and implementation failure will be avoided. This implies companies ought to take a long-term view regarding their digital spend. Since digitalization is likely not to have a linear ROI and may gain a first step benefit only in learning, firms should not be looking only at short-term profits as a yardstick with which to evaluate digital tech investment. Early adoption of digitalization is likely to incur some expenses for adaptations/experiments, and disorganized working within the organization. But these short-run barriers are just one piece of the learning journey of the organization getting the digitalized skills. In addition, businesses cannot simply invest aggressively on hardware, paying lip service to extra investment in research and development, organizational adaptability, and the value of digital knowledge. This is enlightening as firms that use digital technologies integrate the technology use strategies with the innovation practices, ahead of the average, compared with firms that do neither. It means therefore that digitalization was to be a component of a wider business plan centered on investments in growth and development of innovation and skills upgradation. Overall the implications of the findings at the firm level are that digitalization must be followed up with organizational restructuring, skills development, and innovation for growth in productivity.

5.2 Policy Implications

What the results mean for policy makers is that digital policies can be designed differently from the traditional approach of focusing on the provision of subsidies for equipment adoption. The lower-cost new technologies could stimulate companies to adopt new technologies, but the measures may not lead to significant productivity growth. The larger challenge discovered from the study was not access to digital technologies but how firms, and particularly smaller and weaker firms, might use them. It's moving from one-off technology subsidies to a complete digital ecosystem. Beyond just providing low-priced digital infrastructure, this ecosystem would include skill formation systems, advisory support, interoperable digital standards, reliable connectivity, as well as institutional mechanisms to further minimize the cost of upgrading an organization. Practical Implications Policymakers should develop interventions focused on the overall view of constraints to digital transformation for firms. For instance, we would start with digital

skills development as a first priority. Public policy should enable extensive training programs among workers, managers and entrepreneurs in sectors and places where digital capability is still low. Through collaborations that include government, industry, training institutions and universities, targeted curriculums on digital literacy, software user education at workplace or corporate level, data management, automation, digital problem solving, etc., can be made available. Public support of such projects is especially helpful when SMEs do not have readily available internal resources for extensive employee training.

The second priority is digital infrastructure. Productivity gains from the digitalization process depend on reliable internet connectivity, secure data systems, cloud access and supporting infrastructure for logistics and power. Absent these conditions, the firms are likely to encounter high cost for implementation and integration of digital technologies. Policymakers thus need to keep spending on broadband expansion and digital public infrastructure and regionally inclusive connectivity to ensure that digital transformation benefits do not have all befuddled into those already-ready firms or cities.

Third, legislators should encourage standard digital protocols and interoperable systems. One stumbling block to this sort of digitalization is information platforms, data systems, and compliance processes that exist in between firm and sector. For instance, standardized digital frameworks will help mitigate uncertainty, spur communication across the supply chain, and facilitate the compatibility of digital investments. This also helps SMEs as many of them find it difficult to access technology when their systems are intricate, costly or hard to integrate into clients' and suppliers' larger systems. A very significant outcome however is that SMEs need customized assistance for the implementation. Given the evidence that digitalization has a greater impact on larger firms than smaller firms, policy interventions will need to focus on the structural disadvantages faced by small firms. This might constitute programs such as subsidized training programs, digital service centres for businesses, process redesign advisory schemes, easy access to an enterprise digital finance market; and rewards not just for purchasing equipment but for an overhaul of the institution. Policies for SMEs to adopt technology must be developed. Governments also must support the encouragement of complementary investments for R&D and innovation systems. If digitalization is associated with stronger productivity gains and coupled with innovation capability, then industrial and digital policies should combine more closely. Encouraging research cooperation, innovation grants, technology extension services, and platforms for sharing knowledge can transition firms from merely using technology to adopt efficient applications of its integration. Lastly, the results suggest policymaking assessments need to move beyond counting the number of new companies who introduce digital tools. Success should be defined as the degree of productivity, capability, and long-term competitiveness delivered by digitalization. We need more emphasis on outcome-based design of policy and the capture of firm-level digital use, on adapting to digital change and learning and on developing skills.

5.3 Broader Strategic Implication

The significance of this study is wider, showing that digital transformation in a broader context should not be perceived as only a technology agenda, but rather as a systemic process. For the organizations, it means connecting their digital investments to the organization and building human capital. From the perspective of regulators, the implication is to frame the conditions under which organizations can effectively adopt and implement digital technologies. Policies granting only access to hardware or software might promote their adoption in nominal terms, yet such changes will not lead to widespread productivity improvements unless they incentivize investment in skills, infrastructure, standards and institutional support. From this perspective, the problem is not just how much more digitally adopted it is but how great the quality and utility of digital transformation. An approach based on whole-of-ecosystem rather than isolated inputs is,

therefore, more oriented towards productive growth over the long term, and will also mitigate the danger of growing technological differences between advanced firms and the rest of the economy.

6. Conclusion

In this context, the association of digital intensity and firm-level productivity was assessed taking into account non-linearity, firm heterogeneity and complementary abilities. On the basis of firm-level panel results and the econometric methods developed to cope with unobserved heterogeneity and endogeneity, results of the analysis demonstrate that digitalization is positively related to TFP. Our test also demonstrates that high firm digital intensity is associated with higher productivity, although the relationship is not the same for each firm, but instead not automatic nor uniform.

An important conclusion is that the digital-productivity relationship is expected to be a non-linear one. However, productivity gains for economies at low rates of digital adoption seem limited, and can even be offset by adjustment costs, practical issues and learning to use those technologies. But as firms become increasingly engaged digitally, the returns get stronger, indicating threshold effects. That shows that the impact of digital investment starts to pay off much bigger only if it's embedded to the core of the firm's operations and is paired with change within the organization.

It additionally discovers major differences across different firm sizes and industry types: For large firms, there are clearer gains of digitalization in terms of productivity compared to small private firms and medium firms (suggesting variations among firms in terms of finance and managerial skills in addition to the existence of skilled labor). Moreover, firms in high technology industries benefit more than those engaged in traditional industries such as manufacturing where technology adoption is relatively slow. In other words, the impact of digital technologies in terms of productivity depends not only on the characteristics of each particular industry but also on the environment in which they operate.

A very important conclusion drawn from the analysis was that digital technology was effective when complemented by investments in human capital and research and development. As a result, it would yield greater benefits if it is supported by investments in personnel and R&D rather than just purchasing hardware or software. It implies that simply acquiring technology is not sufficient for achieving productivity gains. Skills, readiness of organizations, and knowledge about implementation of new technological processes and decision-making systems are also critical for such changes.

The findings, together give new impetus to literature focusing on digital transformation by supporting the conclusion that firm-level productivity increases depend not only on actual digital adoption itself, but on the intensity, context, and quality of implementation of digital capabilities as well. Therefore, the study contributes to a more developed understanding of digitalization as a capability-building process rather than a simple upgrading of the digital infrastructure.

However, there are limitations to the study. A central limitation revolves around how to measure digital intensity. At the firm level, data on digital investment are quite frequently incomplete and not always sufficient to gauge the true extent, sophistication, or effective use of digital technologies. For example, expenditure-based measures can be an indication of investment, but not necessarily of the extent that a firm has successfully integrated the technology at the enterprise level. Index-based measures, of course, often depend upon the extent and quality of survey responses. Thus, some error in measurement is difficult to avoid.

The second limitation lies in the limited data coverage and lack of comparability. The reliability of estimation could be affected by missing observations, inconsistency in reporting, and differences in accounting practices in firm-level panel datasets. Moreover, even in the case of endogeneity, as it is addressed with the econometric procedure, this causality should be concluded tentatively upon an account

of unobserved time-varying factors that can affect productivity and digital investment. These limitations identify several research directions. A promising category is digital culture within firms. It is interesting to anticipate that companies with more open, adaptive, and innovation-oriented cultures will convert digital technologies into enhanced efficiency. Research will supplement this knowledge by moving beyond formal investment only and including values, leadership styles, and organizational attitudes toward experimentation in digital outcomes.

However, another important issue arises here in relation to the area of considerable significance, taking into account the growing role of virtual remote work and digitally enabled corporate organization. In light of organizations switching to hybrid working conditions and virtual collaboration and coordination, as well as the use of platform management, it is necessary to assess how differences in productivity, collaboration, and organizational effectiveness would impact the situation where new reality takes place: Future research might consider how productivity, collaboration, and organizational differences will impact these differences in the workplace environment. In this regard, studies into whether companies that are able to offer their employees flexible digital workplaces could maximize the value generated through digital investments made into work and by making the most out of such investments should be considered. In addition, this might be useful to examine the heterogeneity of such outcomes across various industries and occupations.

Overall, according to this research, digitalization may positively affect firm productivity. However, some factors have to be taken into account for achieving this result. Of course, everything starts from technological aspects but it is important to take into consideration how these technological tools are going to be used.

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