**Trade Digitization and Domestic Value-Added Rate in Exports**

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**Keywords**: Trade Digitization; DVAR; Cost Markup Effect; Relative Price Effect

**JEL Codes:** F740

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**1. Introduction**

After the 2008 financial crisis, the uncertainty of global trade increased, the expansion of the global value chain (GVC) slowed down, and the development of China's foreign trade faced a severe test. On the one hand, the phenomenon of "manufacturing backflow" in developed countries is becoming increasingly intense, the rise of trade protectionism is becoming increasingly prominent, and the rise of manufacturing in some developing countries has led to a "double-sided attack" of China’s participation in the division of labor in the GVC. On the other hand, China's demographic dividend has gradually subsided, which makes it difficult to provide a strong driving force for the development of foreign trade. In addition, the transformation and upgrading of China's manufacturing industry has not been completed, and a troublesome issue caused by the lack of core technology still exists; there is still a certain distance from innovation activities with high added value[[2]](#footnote-2). Facing the risk of “low-end locking”, new growth drivers for high-quality development must be sought.

With the development of the internet and digital technology, traditional trade relies on internet technology to participate in digital transformation. This change not only makes data, such as trade information, flow more quickly and conveniently transmitted, which helps improve the allocation efficiency of production factors, but also helps the transaction process break through time and space constraints, simplifies the trade process, and profoundly affects many links of trade. Finally, it brings new growth space for trade development and can become a new driving force for trade growth after the demographic dividend. In fact, as early as 2019, the Chinese government proposed to continuously "improve the digital level of trade, form a digital, networked and intelligent development model with data as the core driver, the platform as the support and commercial product integration as the main line". The government also proposed to realize the digital transformation of the whole industry chain and the value chain of foreign trade, build a digital value chain and improve trade added value as an important means of the high-quality development of China's export trade. Therefore, this paper explores the internal relationship and influence mechanism between trade digitization and DVAR in the exports of Chinese manufacturing enterprises, which has important policy implications for transforming the development power of export trade, realizing the upgrading of the GVC and promoting the high-quality development of export trade.

Theoretically, trade digitization aims to transform the trade industry by using the internet and digital technology. With the application of the internet and digital technology to all links of trade, Provide goods and services through the cross-border flow of online data. Existing cross-border e-commerce is a typical stage of trade digitization development (Dai, 2021). Javier and Marie (2017) believe that trade digitization refers to the trade mode and trade behavior of cross-border sales of goods or the cross-border provision of digital services through online retail websites and platforms. Based on this, the trade digitization considered in this paper refers to the business model of taking the internet as the carrier, integrating digital technology with traditional trade, and using a cross-border e-commerce platform to integrate resources and support online transactions, that is, taking the internet as the platform to digitize the relevant links of trade. Alibaba, as the largest e-commerce platform, digitally empowers the enterprises active on the platform through multiple scenes and links, such as technology, finance and logistics, to help realize trade digitization. Most of the existing studies on trade digitization focus on the perspective of the internet. The main effects for enterprises are reductions in production costs, search costs, communication costs and other trade costs; improvement in productivity, alleviation of the problem of resource mismatch, and the promotion of technological progress and R&D innovation (Freund and Weinhold, 2004; Dewan et al.,2003; Jiménez M et al.2014; Yue et al.,2021,Zhang and Zhao,2021).

Research on the DVAR is ongoing. Early research focused on measuring and displaying the performance characteristics of the DVAR in various countries. The input–output table of the WIOD is used to calculate the DVAR (Hummels et al., 2001; Koopman et al., 2012; Timmer et al., 2014). Kee and Tang (2016) creatively refined the data to the enterprise level and measured the DVAR of China for the first time. Studies mainly focus on the influencing factors or economic effects of the DVAR, and the cost markup effect and relative price effect of intermediate goods are the main theoretical mechanisms, which leads scholars to analyze the impact of the cost markup effect and relative price effect of intermediate goods on the DVAR from different perspectives. Mao and Xu (2018) found that foreign capital entry not only has a greater cost markup effect on high-efficiency enterprises and enterprises in industries with high market competition but also expands the types of domestic intermediates and increases the relative price of imported intermediates, which is generally helpful to improve the DVAR. Some scholars adopt the perspective of trade liberalization and believe that the liberalization of intermediate goods trade has a positive effect on the DVAR (Yue, 2019). Other scholars take the perspective of factor market distortion and believe that the race to the bottom competition caused by reducing the price of domestic intermediate products in exchange for the expansion of export scale aggravates the factor market distortion and leads to a positive impact of factor distortion on the DVAR (Gao et al., 2018).

The above studies are mainly conducted from the perspectives of foreign capital entry, trade liberalization or trade facilitation. Unfortunately, there are few studies from the perspective of trade digitization. It is believed that digitization can promote the rise of the GVC and help developing countries participate in high value-added activities (Banga K, 2019). Scholars have conducted research from the perspective of the internet, using websites and broadband data, and proposed that the development of the internet can promote the division of labor in the GVC (Lanz et al., 2018).

The above review shows that there is little research on the impact of the DVAR from the perspective of trade digitization. Some scholars believe that resource allocation efficiency has a negative impact on the DVAR, which seems to contradict the theory. Moreover, there are deficiencies in digital measurement indicators. Most scholars consider whether enterprises have an email address or website (Yadav, 2014; Li and Li, 2017; Ye et al. 2018; Lanz et al., 2018); however, internet use behaviors, such as having an email address or website, do not have a direct connection with enterprise trade behavior, which may make it difficult to accurately reflect whether enterprises realize trade behavior by accessing the internet. Therefore, this paper mainly identifies whether enterprises carry out trade with the help of access to the internet based on whether enterprises have become “Alibaba members”. Then, it explores the impact of trade digitization on the DVAR and its internal mechanism and studies whether trade digitization plays a role through resource reconfiguration.

Therefore, the possible marginal contributions of this paper are as follows. (1) This study gives a clear definition of trade digitization. Moreover, from the new perspective of trade digitization and the micro level, it explores the impact on the DVAR in enterprise exports and explores a new driving force for improving the DVAR. (2) In terms of data selection, this paper uses Alibaba member data to build indicators to measure the level of trade digitization. This indicator makes up for the lack of email and website data and can more intuitively reflect the impact of enterprises' internet access on trade behavior. (3) Based on the theoretical model analysis and combined with the intermediary effect model, this paper tests the impact mechanism of trade digitization on the DVAR, further discusses the negative impact of resource allocation efficiency on the DVAR, and investigates the differential impacts across regions and enterprise types. This paper comprehensively analyzes the internal relationship between trade digitization and the DVAR in the exports of enterprises.

**2. Theoretical model**

This paper extends the theoretical model of Kee and Tang (2016), innovatively introduces data information into the production function as production input factors, and explores the impact mechanism of trade digitization on the DVAR.

2.1. Production level

In the era of the digital economy, data has become a new factor of production and exists in the form of the internet. Hu and Wang (2017) pointed out that becoming a key factor of production requires meeting the conditions of cost advantage, absolute supply capacity and wide application prospects. The cost of data acquisition, storage, processing and analysis is low. Based on the characteristics of replicability and storage, it has unlimited supply capacity. This paper introduces data information, a new production factor, into the following production function:

, (1)

This paper assumes that enterprises produce heterogeneous products, and each enterprise produces only one product, which depends on four production factors: labor, assets, intermediate products and data information. is the total output of enterprise  at time ,  is capital input, is labor input, is intermediate goods input, is data information input, 、、、are elasticity coefficients, is trade digitization and  is productivity. In addition, the following two assumptions are met: (1) ,, which indicates that the higher the level of trade digitization is, the higher enterprise productivity is (Oliner et al., 2018; Huang et al.,2019); and (2) ,, represents that the higher the level of trade digitization is, the more data and information elements can be used for production. The input of intermediate goods comes from domestic  and imported  intermediate goods. The average price of intermediate goods  is jointly determined by the average price of domestic  and imported  intermediate goods, as shown in equations (2) and (3).  is the substitution elasticity of domestic and imported intermediate products, . Trade digitization helps alleviate the information gap between domestic and foreign product prices, so it is assumed that there is a functional relationship between domestic intermediate price and trade digitization, ,. This means that the higher the level of trade digitization is, the lower the information asymmetry is, which eases factor price distortion and increases the price of domestic intermediates.

 (2)

 (3)

The profit function of an enterprise can be expressed as the difference between the total income of the enterprise and the total cost of each input factor. The total revenue of the enterprise is, and  is the average price of the final product. The profit function of the enterprise is:

 (4)

, , , and  are the average prices of capital, labor, data information and intermediate products, respectively. From the maximization of enterprise profits:

 (5)

 is the optimal production cost under the condition of enterprise profit maximization, and the available marginal production cost is:

 (6)

2.2. Intermediate level

The optimal price and quantity of intermediate products can be solved by minimizing the cost as equations (8) and (9), and equation (10) is the cost of imported intermediate products.

，   (7)

 (8)

 (9)

 (10)

2.3 DVAR

The DVA can be understood as the total income of the enterprise minus the income brought by the import of intermediate products. The proportion of the income of the import of intermediate products in the total income of the enterprise is [[3]](#footnote-3), so the DVAR is:

 (11)

 (12)

It can be seen from equation (12) [[4]](#footnote-4)that there are cost markup effects () and relative price effects of intermediate goods () in the DVAR. ,. The higher the cost markup is, the higher the relative price of intermediate goods and the higher the DVAR. We can expand to obtain equation (13). Furthermore, by using the DVAR to derive the level of trade digitization, it is not difficult to find the marginal effect of trade digitization on the DVAR as equation (14).

 (13)

 (14)

. It can be seen from equation (14) that the symbol of a needs to be discussed separately from the cost markup effect and relative price effect of intermediate goods. , so ;，so. The higher the trade digitization is, the higher the DVAR is under the cost markup effect and the lower the DVAR is under the relative price effect of intermediate goods. Therefore, the impact of trade digitization on the DVAR depends on the relative size of the cost markup effect and the relative price effect of intermediate goods. Based on the above, this paper puts forward proposition 1:

**Proposition 1:** The impact direction of trade digitization on the DVAR depends on the sum of the cost markup effect and the relative price effect of intermediate goods, and trade digitization has an uncertain impact on the DVAR. Theoretically, it is considered to have a positive impact.

Further exploration. First, from the perspective of the cost markup effect, trade digitization can reduce the search cost and communication cost of enterprises (Anderson and wincoop, 2004), improve the convenience of communication by alleviating information asymmetry, and make it easier for enterprises to obtain price information. Relying on the e-commerce platform, trade digitization greatly reduces the difficulty for enterprises to obtain orders. The original complex and time-consuming offline transaction process can be simplified and efficiently realized through online operation, reducing the transaction cost of enterprises. Moreover, trade digitization simplifies the original transaction process, which can promote the professional division of labor and cooperation and reduce production costs (Brynjolfsson and Hitt, 2000; Kuhn and skuterud, 2004; yushkova, 2014; Pisano et al., 2015). In conclusion, digitization can reduce enterprise trade costs through various channels, solve the problem of enterprise R&D and innovation funds, and help improve enterprise total factor productivity. In addition, the internet can alleviate export information asymmetry, improve the degree of market competition, and force enterprises to continuously improve productivity to maintain their market position (Pan and Xiao, 2018). Trade digitization increases trade opportunities and improves trade efficiency. The effective play of the "learning effect" and "demonstration effect" strengthens the technology absorption capacity of enterprises to improve their productivity and increase the domestic added value of their exports through the cost markup effect (Liu and Wan,2021). Based on the above, this paper proposes Proposition 2:

**Proposition 2:** From the perspective of the cost markup effect, trade digitization can improve the DVAR by improving total factor productivity.

From the perspective of the relative price effect of intermediate goods, this paper posits that trade digitization mainly affects the DVAR by the mismatch of enterprise resources. The internet can improve the resource allocation efficiency of enterprises by reducing the uncertainty of information(Guo and luo, 2016) And China’s factor price presents a negative distortion, and the price of production factors is underestimated (Geng and Liao, 2016). When resource allocation efficiency is improved, this negative distortion is alleviated, and the price of domestic factors is increased, resulting in an increase in the average price of domestic intermediate products because enterprises pursue the lowest production cost and choose to use foreign factors to produce intermediate products. The relative price of intermediate goods  decreases, resulting in a reduction in the DVAR (Gao et al., 2018). Therefore, the higher the level of trade digitization is, the higher the resource allocation efficiency of the enterprise, resulting in an increase in the average price of domestic imports and a reduction in the relative price of intermediate goods. Therefore, the lower the DVAR is, the more likely the problem of "low-end embedding" is to arise. Based on the above, this paper puts forward proposition 3:

**Proposition 3:** From the perspective of the relative price effect of intermediate goods, trade digitization can affect the DVAR by improving the resource allocation efficiency of enterprises. However, the problem of "low-end embedding" is the illusion that trade digitization is not conducive to the improvement in the DVAR.

**3. Data and methods**

3.1. Data

In this paper, enterprise-level financial data are from the China Industrial Enterprise Database, and enterprise import and export trade data are from the China Customs Database. We merge the two databases by the method of Yu (2015) and use the data from 2004 to 2013. The Alibaba member data are matched with the above sample set by the enterprise name, and finally, 155,164 samples are obtained.

3.2. Measurement of trade digitization

Based on the definition of trade digitization, it has close relationship with the internet platform. Most previous studies construct the internet use index according to whether an enterprise uses an email address and has a website. This method is reasonable. Therefore, this paper takes whether the enterprise has an email address and a website as the proxy index of trade digitization. Each year beginning with the year when the enterprise gains an email address and website, recorded as  and , respectively, takes the value 1; otherwise, 0. However, this method has the problems of “ownership and use”[[5]](#footnote-5). Therefore, this paper additionally considers whether enterprises use Alibaba to measure trade digitization. As a representative of the continuous development of trade digitization in recent years, cross-border e-commerce enables enterprises to carry out trade activities digitally, which is suitable to reflect the level of trade digitization. Specifically, this paper crawled Alibaba member data to obtain the enterprise name and first year of membership. Only enterprises that have become members can use Alibaba for trade. Whether an enterprise is an Alibaba member is taken as the proxy index of trade digitization. Each year beginning with the year when the enterprise becomes an Alibaba member takes the value 1; otherwise, 0, recorded as.

3.3. Measurement of the DVAR

Referring to the measurement methods of Kee and Tang (2016) and Zhang and Tang (2018), this paper calculates the DVAR on the basis of considering problems such as indirect import and export, implied value and capital goods depreciation. The specific expression is as follows:

 (15)

For pure general trade enterprises () and pure processing trade enterprises (), their DVAR can be expressed as:

 (16)

 (17)

where  is the import value included in the export of the enterprise;  is the share of indirect imports;  is the direct import scale;  is the gross domestic product of the enterprise, expressed by the total sales volume of the enterprise;is export scale;  is the share of foreign added value implied in domestic exports; and  is the depreciated value of imports.

For mixed trading enterprises ():

 (18)

where  and , respectively, represent the ratio of general trade exports and processing trade exports to total exports.

3.4. Econometric model

This paper uses the PSM-DID method to conduct an empirical study. First, refer to the method of Yue et al. (2017) to process the samples. The enterprises that have Alibaba membership, an email address and a website during the sample period are defined as the experimental group, . The enterprises that do not have Alibaba membership, an email address or a website during the sample period are defined as the control group, . Finally, the nearest neighbor 1:3 matching method is used for logit estimation. The matched samples have a large common value range, the standard deviation is reduced, and the absolute value is within 5%, close to the "0 line", which passes the balance test. Then, a double difference model with two-way fixed effects is established to regress the matched samples:

 (19)

where is trade digitization, and ,is the set of , , and ,The multiplicative results are expressed by , , and . is the control variables: enterprise age (), expressed by the difference between the year of business opening and the current year; enterprise scale (), expressed as the logarithm of the number of employees; the ratio of capital to labor (), expressed by the logarithm of the ratio of the net value of fixed assets of the enterprise to the number of employees; whether the enterprise is a state-owned enterprise (), where state-owned enterprises take a value of 1, and otherwise, 0; is the individual fixed effect;  is the year fixed effect; and  is the error term.

3.5. Descriptive statistics

**Table 1** Descriptive statistics of the data

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variables | Mean | Min | Max | S. Dev | Observations |
| dvar | 0.8190 | 0 | 1 | 0.2307 | 155 164 |
| albb | 0.0065 | 0 | 1 | 0.0801 | 155 164 |
| email | 0.2509 | 0 | 1 | 0.4335 | 98 545 |
| web | 0.1907 | 0 | 1 | 0.3928 | 98 545 |
| size | 5.7228 | 2.0794 | 12.2009 | 1.1295 | 155 164 |
| kl | 4.0617 | -5.2585 | 13.9601 | 1.3896 | 155 164 |
| age | 21.4163 | 7 | 169 | 7.9090 | 155 164 |

**4. Results and discussion**

4.1. Basic regression

It can be seen from columns (1) - (3) of Table 2 that under the PSM-DIDI method, the trade digitization described by different methods has a significant positive impact on the DVAR. Table 2 columns (4) - (6) are the estimation results of the full sample fixed effect model, and the same results can still be obtained, which verifies proposition 1 of this paper. The effect of trade digitization on the DAVR is mainly positive, and the positive effect brought by the cost markup effect is dominant. In terms of control variables, the enterprise scale is significantly positive. The larger the scale of an enterprise is, the higher the efficiency of using trade digitization, which can give full play to the advantages of the internet and improve the DVAR. The higher the capital intensity of an enterprise is, the more conducive it is to the improvement in the DVAR. The age of enterprises has no significant effect on the DVAR. Compared with private enterprises and foreign enterprises, state-owned enterprises have a lower DVAR.

**Table 2** Basic regression

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | (1) | (2) | (3) | (4) | (5) | (6) |
| ALBB | 0.0285\*\*\* |  |  |  |  |  |
|  | (0.0108) |  |  |  |  |  |
| EMAIL |  | 0.0184\*\*\* |  |  |  |  |
|  |  | (0.0048) |  |  |  |  |
| WEB |  |  | 0.0129\*\* |  |  |  |
|  |  |  | (0.0056) |  |  |  |
| albb |  |  |  | 0.0305\*\*\* |  |  |
|  |  |  |  | (0.0096) |  |  |
| email |  |  |  |  | 0.0179\*\*\* |  |
|  |  |  |  |  | (0.0047) |  |
| web |  |  |  |  |  | 0.0139\*\* |
|  |  |  |  |  |  | (0.0056) |
| size | 0.0345\*\*\* | 0.0062\*\* | 0.0071\*\* | 0.0240\*\*\* | 0.0049\*\* | 0.0049\*\* |
|  | (0.0027) | (0.0027) | (0.0030) | (0.0013) | (0.0022) | (0.0022) |
| kl | -0.0018 | -0.0039\*\* | -0.0060\*\*\* | -0.0004 | -0.0041\*\*\* | -0.0040\*\*\* |
|  | (0.0020) | (0.0018) | (0.0019) | (0.0009) | (0.0014) | (0.0014) |
| age | 0.0001 | 0.0000 | 0.0002 | -0.0000 | 0.0002 | 0.0002 |
|  | (0.0004) | (0.0002) | (0.0002) | (0.0002) | (0.0002) | (0.0002) |
| state | -0.0361\*\*\* | -0.0289\*\*\* | -0.0335\*\*\* | -0.0155\*\*\* | -0.0305\*\*\* | -0.0307\*\*\* |
|  | (0.0115) | (0.0062) | (0.0062) | (0.0031) | (0.0047) | (0.0047) |
| Individual effect | YES | YES | YES | YES | YES | YES |
| Year effect | YES | YES | YES | YES | YES | YES |
| Constant | 0.6160\*\*\* | 0.7350\*\*\* | 0.7340\*\*\* | 0.6750\*\*\* | 0.7410\*\*\* | 0.7420\*\*\* |
|  | (0.0214) | (0.0203) | (0.0223) | (0.0110) | (0.0160) | (0.0160) |
| *N* | 33 164 | 62 507 | 51 242 | 155 164 | 98 545 | 98 545 |
| *within-R*2 | 0.070 | 0.086 | 0.088 | 0.049 | 0.082 | 0.082 |

*Notes*: Clustering robust standard error in brackets, \*\*\* is P < 0.01, \*\* is P < 0.05, \* is P < 0.1. The following table is the same.

4.2. Robustness test

This paper tests the robustness of the model in the following two ways.

(1) Change the enterprise sample. This paper deletes the computer communication industry (industry code 40) for the robustness test. Enterprises in the communication equipment, computer and other electronic equipment manufacturing industries are more likely to use internet platforms and digital technology. These industries have a natural correlation with digitization, which will have an impact on the research. Therefore, this paper deletes enterprises in this industry and reruns the regression. Column (1) of Table 3 shows that trade digitization still has a significant positive impact on the DAVR. Excluding the natural correlation between enterprises in the computer industry and digitization, the results obtained are still consistent with those of the benchmark regression and pass the robustness test.

(2) Add fixed effects of provinces and industries. To eliminate the unobservable impact caused by the changes at the provincial and industry level over time, the interaction items between year and province and year and industry are added. The results are shown in column (2) of Table 3. Trade digitization still has a positive and significant impact on the DVAR, which is consistent with the previous research results and passes the robustness test.

**Table 3** Robustness test

|  |  |  |
| --- | --- | --- |
|  | (1) change the sample | (2) add fixed effects |
| albb | 0.0253\*\*\* | 0.0257\*\* |
|  | (0.0093) | (0.0103) |
| Control variables | YES | YES |
| Year and Regional effect | NO | YES |
| Year and industry effect | NO | YES |
| Individual effect | YES | YES |
| Year effect | YES | YES |
| Constant | 0.6790\*\*\* | -1.2930 |
|  | (0.0113) | (1.2471) |
| *N* | 140 858 | 155 164 |
| *within-R*2 | 0.047 | 0.053 |

*Notes*: To save space, only the results of albb are reported. The following table is the same.

4.3. Influence mechanism test

In the theoretical analysis section, this paper discusses the potential impact mechanism of trade digitization on enterprise DVAR from the perspectives of cost and efficiency. Based on this logical basis, this paper first verifies the impact of trade digitization on enterprise total factor productivity and resource allocation efficiency by establishing an intermediary effect model and performs regression analysis using models (20) - (22). Taking total factor productivity and resource allocation efficiency as explanatory variables, this paper explores the marginal effect of trade digitization, further studies the impact of trade digitization on the DVAR, and constructs the following regression equation:

 (20)

 (21)

 (22)

 include ;  is total factor productivity, using accounting with the Olley and Pakes (1996) method.  is resource allocation efficiency, referring to the methods of Hsieh and Klenow (2009), where the higher the resource allocation efficiency is, the smaller the distortion of capital and labor, which can be reflected by the marginal value of capital and labor. Capital distortion () and labor distortion () can be determined from the production function .  is nominal output, , , expressed by the industrial added value of the enterprise, and . is total wages. The resource allocation efficiency index is , and the smaller the index is, the higher the resource allocation efficiency(Wang and Li, 2021).

 (23)

Columns (1) and (2) of Table 4 show that the impact coefficient of trade digitization on total factor productivity is significantly positive and the regression coefficient on resource allocation efficiency is significantly negative; that is, trade digitization can improve total factor productivity and resource allocation efficiency. Column (3) of Table 4 shows that trade digitization still has a positive significant impact on the DVAR, and total factor productivity has a positive significant impact on the DVAR; that is, trade digitization can improve the DVAR by improving total factor productivity. Verified Proposition 2 of this paper. Column (4) of Table 4 shows that the resource allocation efficiency has a significant positive impact on the DVAR; that is, the lower the resource allocation efficiency is, the higher the DVAR. After trade digitization improves resource allocation efficiency, it indirectly inhibits the DVAR, which verifies proposition 3 of this paper.

From the above analysis, it can be seen that resource allocation efficiency has a negative impact on the DVAR; the lower the resource allocation efficiency is, the higher the DVAR, which seems to be contrary to common sense and entails the problem of "low-end embedding". By definition, the DVA is a difference variable. The increase in the DVA can be the upper limit of improving the technical level or the lower limit of reducing the input cost. The resource allocation efficiency can be reduced in exchange for a high DVA by reducing the price of production factors and the price of domestic intermediate products. Trade digitization improves resource allocation efficiency, alleviates the negative distortion of China's factor price, and leads to an increase in the lower limit of the input cost, resulting in a reduction in the difference and inhibiting domestic added value. However, exchanging low costs for high added value is not a beneficial and effective way to improve the DVA. The factor market distortion caused by government rent-seeking behavior can significantly inhibit the innovation efficiency and R&D investment of enterprises (Gill and Kharas, 2007; Claessens et al., 2008). Moreover, innovative R&D helps improve the DVA. Therefore, this paper suggests the improvement in the efficiency of resource allocation and the continuous development of the domestic technology level to improve the DVAR.

To better illustrate this problem, this paper adds the R&D innovation level () to describe the domestic technology level and uses the ratio of new product output value to industrial sales output value. Furthermore, the impact of the R&D innovation level on the DVAR is explored by constructing interactive items.

According to the estimation results in column (5) of Table 4, the interaction term between enterprise R&D innovation level and resource allocation efficiency is significantly negative, indicating that the negative marginal effect of resource allocation efficiency on the DVAR is affected by the R&D innovation level, and its negative impact decreases with the improvement in enterprise R&D. In summary, although it seems that the lower the resource allocation efficiency is, the greater the promotion effect on the DVAR, this method of exchanging low cost for high value is not a beneficial method to enhance the DVA. In contrast, enterprises should optimize the allocation of resources, enhance their R&D and innovation ability, and improve the DVAR from the perspective of cultivating their own technology to realize a long-term virtuous cycle.

**Table 4** Influence mechanism test

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Explained variable | (1) tfp | (2) miss | (3) dvar | (4) dvar | (5) dvar |
| albb | 0.0961\* | -0.0061\* | 0.0286\*\*\* | 0.0314\*\*\* |  |
|  | (0.0559) | (0.0036) | (0.0094) | (0.0097) |  |
| tfp |  |  | 0.0200\*\*\* |  |  |
|  |  |  | (0.0009) |  |  |
| miss |  |  |  | 0.1980\*\*\* | 0.2080\*\*\* |
|  |  |  |  | (0.0109) | (0.0147) |
| new\_miss |  |  |  |  | -0.2120\*\*\* |
|  |  |  |  |  | (0.0413) |
| Control variables | YES | YES | YES | YES | YES |
| Individual effect | YES | YES | YES | YES | YES |
| Year effect | YES | YES | YES | YES | YES |
| Constant | 5.6760\*\*\* | 0.2020\*\*\* | 0.5610\*\*\* | 0.6350\*\*\* | 0.7290\*\*\* |
|  | (0.0573) | (0.0055) | (0.0127) | (0.0114) | (0.0166) |
| *N* | 155 160 | 155 109 | 155 160 | 155 109 | 98 057 |
| *within-R*2 | 0.050 | 0.045 | 0.057 | 0.053 | 0.101 |

4.4. Heterogeneity test

(1) Enterprise type heterogeneity

Cost reduction is an important mechanism for trade digitization to improve the DVAR. The substitution between digital technology and labor resources can effectively reduce labor costs (Acemoglu et al., 2014; Chen and Zhou, 2021). The internet can reduce the proportion of labor-intensive enterprises and promote the transformation and upgrading of labor-intensive enterprises to capital- and technology-intensive enterprises. Considering the dependence on labor resources among different types of enterprises, this paper divides enterprises into labor-intensive and capital-intensive enterprises to explore the impact of trade digitization on manufacturing export enterprises of different factor-intensive types.

According to the results in (1) - (2) of Table 5, trade digitization has a more significant effect on the export and DVAR of labor-intensive enterprises but has no significant impact on capital-intensive enterprises. The internet platform enables enterprises to complete consultation and sales online, reducing the demand for labor resources in all links of trade. The advantages of big data allow the automatic analysis and processing of information materials, thereby reducing manual reading and processing time, improving work efficiency, improving the integration and sharing of internal resources and information, and improving the efficiency of production, manufacturing and operation management. Online platform recruitment channels can recruit outstanding talent in the industry, improve the efficiency of human resource allocation, reduce personnel salary costs caused by unnecessary human resource expenses, and meet the matching demand of human resource quality and scale caused by the growth of the value chain (Caselli and Coleman, 2006; Qi and Ren, 2021). The reduced cost enables enterprises to obtain more funds to improve product quality and production efficiency, which is conducive to the improvement in the DVAR. Labor-intensive enterprises are more dependent on labor, and trade digitization has a more obvious substitution effect on labor resources, while capital-intensive enterprises have higher requirements for technical equipment and greater dependence on investment, so trade digitization has no significant impact on their DVAR.

(2) Regional heterogeneity in the internet level

There are also differences of trade digitization in the development level of the internet in the regions where enterprises are located. The China internet development report 2020[[6]](#footnote-6) comprehensively evaluates the internet development degree of each province. The results show that Beijing, Guangdong, Shanghai, Jiangsu, Zhejiang, Shandong, Sichuan, Fujian, Tianjin, Chongqing and other places have high scores, ranking in the top 10. In this paper, the above provinces are categorized as areas with a high internet development level, and the other provinces are considered areas with a low internet development level to explore whether there are differences in the impact of trade digitization on the DVAR under different internet development levels.

Columns (3) and (4) of Table 5 show that trade digitization has a positive and significant impact on the DVAR in areas with a high internet development level but has no significant impact in areas with a low internet development level. The level of internet development and digitization are highly integrated and interlinked. Internet development provides enterprises with internet technology and mode and empowers traditional industries. Areas with a high internet development level have a higher degree of industrial agglomeration and more complete supporting facilities to promote enterprises to improve their digital technology ability and realize digital transformation, which benefits traditional trade industries. With the continuous improvement in the trade digitization level, it is easy to form an efficient value chain division system and promote the rise of the value chain. In areas with a low internet development level, infrastructure and digital development are relatively backward, and the integration of trade industry and digital development is difficult, resulting in no significant impact of trade digitization on the DVAR.

**Table 5** Heterogeneity test

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | (1) labor-intensive | (2) capital-intensive | (3) high internet development level | (4) low internet development level |
| albb | 0.0394\*\*\* | 0.0153 | 0.0330\*\*\* | -0.00872 |
|  | (0.0145) | (0.0126) | (0.0102) | (0.0169) |
| Control variables | YES | YES | YES | YES |
| Individual effect | YES | YES | YES | YES |
| Year effect | YES | YES | YES | YES |
| Constant | 0.7130\*\*\* | 0.6300\*\*\* | 0.6760\*\*\* | 0.6710\*\*\* |
|  | (0.0181) | (0.0211) | (0.0117) | (0.0310) |
| *N* | 77 582 | 77 582 | 137 255 | 179 09 |
| *within-R*2 | 0.040 | 0.053 | 0.050 | 0.040 |

**5. Conclusions**

The continuous integration of the internet, digital technology and traditional industries has led the digital industry to empower and transform traditional industries on a large scale and reconstruct the traditional industrial chain, value chain and supply chain. Trade digitization has become an important means to realize the rise of the value chain and high-quality development.

This paper explores the impact of trade digitization on the DVAR in the exports of enterprises and draws the following conclusions:

First, trade digitization can significantly improve the DVAR in the exports of enterprises. The higher the level of trade digitization is, the more conducive it is for enterprises to expand the scope of information, understand and learn cutting-edge technologies, improve total factor productivity and reduce trade costs to promote the DVAR. Moreover, trade digitization can alleviate information asymmetry, improve the convenience of communication and improve resource allocation efficiency. However, due to the problem of "low-end embedding" in the relative price effect of intermediate products, digitization may appear to be not conducive to the improvement in the DVAR. However, trade digitization has a positive impact on the DVAR as a whole; that is, the higher the level of trade digitization is, the more conducive it is for enterprises to improve the DVAR.

Second, the regression results of the intermediary effect show that from the perspective of the cost markup effect, trade digitization helps enterprises increase the DVAR by improving productivity. From the perspective of the intermediate price effect, trade digitization appears to be not conducive to the improvement in the DVAR by improving resource allocation efficiency. The negative impact of resource allocation efficiency on the DVAR entails the risk of "low-end embedding" by exchanging low cost for high value, but the improvement in enterprise R&D and innovation ability can alleviate the inhibitory effect of resource allocation efficiency on the DVAR.

Third, from the perspective of enterprise type and location, trade digitization plays a more significant role in improving the DVAR of labor-intensive enterprises and enterprises in areas with a high internet development level but has no significant impact on capital-intensive enterprises and enterprises in areas with a low internet development level. The advantage of trade digitization has a more obvious effect on enterprises that depend on the labor force. In addition, the regional economic level, infrastructure and digital development degree affect the extent of the advantage offered by trade digitization.

Based on the above research conclusions, this paper puts forward the following policy suggestions:

First, the government should actively promote the development of trade digitization, continuously improve the integration of trade with the internet and digital technology, build high-standard infrastructure, facilitate the free flow of data elements, and fully integrate digitization into all links of trade. Combined with local resource endowments, measures should be adjusted to local conditions, and digital development should be accelerated. Integrated with trade in goods and trade in services, trade in goods can provide more demand for trade in services and give full play to the advantages of digital information, which is not only conducive to the exchange and service of all links of the value chain but also reduces the cost of relevant trade in services. The saved cost can be invested into R&D and innovation, and the product quality can be continuously improved, so as to improve the DVAR and enhance China's position in the GVC.

Enterprises should seize the development opportunity of "trade digitization", create and cultivate digital thinking, pay more attention to the development of digital trade, skillfully use various internet tools and digital technologies, use the "digital dividend" to improve their innate capacity, make accurate and effective decisions in combination with big data, implement digital management and improve operation efficiency to reduce trade costs, improve production efficiency and optimize resource allocation. Moreover, attention should be given to the cultivation of talent and financial support in the digital industry, the development of digital technology, and the improvement in the R&D and innovation level of enterprises. We should expand access to information, create new export channels, obtain more high-quality spillover effects, improve the DVA and improve market competitiveness by expanding trade openness.

Third, while encouraging cross-border exchanges, we should support good supervision, constantly introduce advanced value chains, promote the outward transfer of backward production capacity, improve the integrated production network in China and abroad, reduce trade barriers, standardize relevant policy systems, ensure that risks are controllable while sharing data and information resources, integrate and connect domestic information technology with foreign countries, and ensure internet security. On the premise of a relatively safe network environment, we can give full play to the advantages of trade digitization and promote it as a strong and reliable driving force for the rise of the GVC and economic development.

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