Does Cross-Border E-Commerce Contribute to the Growth Convergence? An Analysis Based on Chinese Provincial Panel Data

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ABSTRACT

The impact of cross-border e-commerce (CBEC) on international trade is prominent in recent years. The authors extend the international trade model with heterogeneous firms to include CBEC export and deduce that CBEC lowers the capability threshold for export. Firms and regions with different capabilities are affected differently, but the total regional export is increasing. In the empirical analysis section, they use panel data from 31 provinces in China from 2015 to 2018 and construct proxy variables for CBEC with CBEC comprehensive pilot zones and CBEC exporters. They find that CBEC contributes to economic growth and economic convergence. The underlying mechanisms include the convergence of regional exports and total factor productivity, while the convergence of capital isn't supported by the results.

KEYWORDS

Capability Threshold, Cross-Border E-Commerce, Economic Convergence, Economic Growth, Export

1. INTRODUCTION

With a leading growth rate, China's economic volume ranks second globally, but its internal development gap between regions is prominent, the trend of which is an important indicator for assessing the coordinated development of regional economies.

Economic convergence is subdivided into σ convergence, $\hat{a}$ convergence, and club convergence. Xavier and Sala-i-Martin (1996) proposed $\hat{a}$ convergence and σ convergence. $\hat{a}$ convergence occurs when the level value at the beginning of the period has a negative effect on the growth rate. If the relationship holds without any control variable, it is called absolute convergence. If the control variable is required, it is called conditional convergence. σ convergence refers to the situation where the difference in level values gradually disappears with time, and the difference is usually measured by the standard deviation. Danny (1996) proposed the club convergence that some of the country's initial

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characteristics caused the country to form groups, and different groups of countries showed different convergence trends. To test whether the economic growth of a country or region converges in the real world, scholars have conducted a lot of empirical studies. Most of the research conclusions support the existence of economic growth convergence (Cheng et al., 2020; Luintel et al., 2020; Startz, 2020).

Numerous studies have attempted to measure the regional economic development gaps and economic convergence in China, and explained the reasons for their formation (Cai et al., 2002). Some studies explained the gap from the perspective of trade (Sun and Tadiwanashe, 2019; Wang and Wei, 2020). Differences in opening contribute to the gap in economic development through the effects of factor concentration, economies of scale, and technology introduction, and the convergence of productivity is an important mechanism for regional economic convergence. There is a strand of literature noticing e-commerce increases productivity (Liu et al., 2013; Falk and Hagsten, 2015; Alberto, 2017), and then it promotes economic growth, but there is no literature focusing on the effect of cross-border e-commerce (hereinafter referred to as CBEC) on economic growth alone. Different from the existing papers, this article focuses on the impact of CBEC on the regional economic convergence.

Similar to the impact of ICT on trade (Freund and Weinhold, 2002, 2004; Allen, 2014; Fernandes et al., 2019; Ndzendze and David, 2019), CBEC reduces transaction cost and weakens the hindrance of distance (Hortacsu et al., 2009; Lendle et al., 2016), therefore CBEC affects exports positively (zhongwei, 2017), especially for SMEs (OECD, 1999; Jansen et al., 2016). The shortcomings of the existing literature are: despite much discussion about CBEC, there is a lack of a systematic framework for analyzing the impact of CBEC on exports. Also, the proxy variables used for e-commerce cannot separate the role of CBEC from other functions of the Internet.

Cross-border e-commerce is essentially a way of export, the occurrence of trade depends on factors like comparative advantages and economies of scale (Ting et al., 2013; Kim et al., 2017; Ángel et al., 2018;). The more open areas may utilize CBEC to further expand export and strengthen its scale effect, and new exporters there can also benefit from industrial agglomeration. Besides, CBEC relies on the same infrastructure as domestic e-commerce, and the operation of CBEC platforms is similar to those of domestic e-commerce. Cross-border e-commerce is more accessible in developed e-commerce regions. Therefore, the emergence of CBEC may widen the gap between the developed areas of export and e-commerce and the less developed areas. However, in less developed regions, there may be more enterprises under the export capability threshold and more room for productivity improvement. The impact of CBEC lowering export thresholds just makes the underutilized production capacity and production factors fully utilized. Consequently, the economic growth rate may experience a substantial increase, accelerating its narrowing of the gap with developed regions (Kneller and Jonathan, 2016; Brandt et al., 2017; Barber and Ernesto, 2018). So, whether the development of CBEC accelerates the catching up of less developed regions and promotes economic convergence is revealed in this article.

This paper extends Johnson (2012) 's model of international trade with heterogeneous firms to include the impact of CBEC on the firm's export behavior and bilateral trade. We derive CBEC lowers the capability threshold of export and increases the aggregate regional export value. And the extent to which CBEC influences regional export depends on the regional capacity level.

In the empirical section, this paper combines the statistical data of China Statistical Yearbook, the statistical yearbooks of provinces, and the statistics of Alibaba International Station to construct panel data of 31 provinces in China from 2015 to 2018 to test how CBEC influenced regional economic convergence and export growth. This paper uses the number of CBEC export merchants and the number of CBEC comprehensive pilot zones in each province as proxy variables to the intensity of CBEC applications. Through the estimation of the fixed-effect model, we draw to the basic conclusion that CBEC promotes economic convergence in China. To check the robustness of the conclusion, indicators of the degree of private economic development and inter-provincial trade potential are added as control variables into the benchmark model. The average annual growth rate

of real per capita output during three years is used instead. We also use the system GMM method and instrumental variable method. The basic conclusion still holds. We also find that CBEC has no significant difference in promoting economic growth in eastern and mid-western provinces, but it weakens the trend of economic convergence of eastern provinces. To explore the mechanisms of CBEC on economic growth, we first examine the impact of CBEC on exports and find that CBEC promotes the narrowing of differences in inter-provincial international trade. Next, we find CBEC promotes the convergence of labor input and the divergence of human capital, but it doesn't affect the growth of physical capital. As for total factor productivity, we find CBEC promotes the followers to catch up with the productivity of the economically leading regions and it promotes the convergence of technological efficiency and pure technology growth.

This article contributes to the literature in two ways. Firstly, we derive theoretically that CBEC lowers the export threshold for firms and increases regional exports. Secondly, we use the provincial panel data of export merchants at Alibaba International Station to test the effect of CBEC on economic growth for the first time.

2. THEORETICAL FRAMEWORK

Johnson (2012) developed the trade model with heterogeneous firms proposed by Helpman et al. (2008). We modify it appropriately and use it to describe the scenario without a CBEC platform. Next, we introduce CBEC platforms and focus on the relationship between trade costs and export thresholds, and the relationship between regional capacity and export volume changes. We show the impact of CBEC on export behavior and regional exports.

2.1 Consumption

Assume the rest of the world (*ROW*) outside of China as a whole and the only export destination of China. The representative individual is assumed to consume continuous heterogeneous goods and supply labor force inelastically. Let the product category be ω and the product category set for area i be Ω_i . Assume the utility function takes the Dixit-Stiglitz form: $U_i = \left(\int_{\omega \in \Omega_i} [\tilde{x}(\omega)]^{(\sigma-1)/\sigma} d\omega \right)^{\sigma/(1-\sigma)}$,

where $\tilde{p}_i(\omega) = p_i(\omega) / q(\omega)$ and $\sigma > 1$ is the elasticity of substitution between varieties. The quantity measured in units of utility is denoted by $\tilde{x}(\omega)$ and the relationship between the utility quantity and the physical quantity is shown by $\tilde{x}(\omega) = q(\omega)x_i(\omega)$, where product quality ($q(\omega)$) represents consumers' multi-dimensional valuation of product characteristics of a physical unit.

$p_i(\omega)$ denotes the price of a physical quantity of the product and the price adjusted by quality is expressed in $\tilde{p}_i(\omega) = p_i(\omega) / q(\omega)$. Then, the physical quantity consumed by area i is shown by $x_i(p_i(\omega), q(\omega)) = q(\omega)^{\sigma-1} p_i(\omega)^{-\sigma} \tilde{P}_i^{\sigma-1} E_i$, and the utility quantity is $\tilde{x}_i(\tilde{p}_i(\omega)) = \tilde{p}_i(\omega)^{-\sigma} \tilde{P}_i^{\sigma-1} E_i$, where $\tilde{P}_i = \left(\int_{\omega \in \Omega_i} [\tilde{p}_i(\omega)]^{1-\sigma} d\omega \right)^{1/(1-\sigma)}$ and E_i is the total expenditure of area i .

2.2 Production

Assume each of the 31 provincial regions in China (excluding Hong Kong, Macau, and Taiwan in China) is a different region i , there are N_i manufacturers in each region, and each manufacturer produces a heterogeneous good with constant returns to scale in the monopolistically competitive market. Manufacturers differ in unit production cost c and product quality q . The firm characterized by $\{c, q\}$ produces a product of quality $Q_i q$ at marginal cost $C_i c$, where C_i and Q_i are the region-specific components. The ratio of quality to cost $A_i a$ is defined as the capability of the manufacturer,

where $a \equiv \frac{q}{c}$ is the firm-specific capability and $A_i = \frac{Q_i}{C_i}$ is the region-specific capability. We can use $\{c, q\}$ or $\{a, q\}$ describe the category ω .

Each firm chooses whether to enter the market and price it. Entering the local market does not involve entry costs and trade costs. To simplify, we do not consider the trade within provinces and the trade between different provinces, but only consider the trade between the 31 provinces and *ROW*. When entering the *ROW* market, manufacturers in region i incur the fixed cost f_{ij} (for convenience of expression, the entry cost of i to *ROW* (f_{iROW}) is abbreviated as f_{ij} , the same below), and the iceberg trade cost which includes transportation cost and average transaction cost. To export one unit of product to *ROW*, the manufacturer needs to ship $\tau_{ij} > 1$ units of product.

Each manufacturer sets the ex-factory price based on the markup pricing $p_i(c) = \left(\frac{\sigma}{\sigma-1}\right) C_i c$

and the quality-adjusted price is $\tilde{p}_i(c, q) = \left(\frac{\sigma}{\sigma-1}\right) \frac{C_i c}{Q_i q}$. These two prices can also be expressed by,

$p_i(a, q) = \left(\frac{\sigma}{\sigma-1}\right) \frac{Q_i q}{A_i a}$ and $\tilde{p}_i(a) = \left(\frac{\sigma}{\sigma-1}\right) \frac{1}{A_i a}$, respectively. The export prices are $p_{ij}(a, q) = \tau_{ij} p_i(a, q)$ and $\tilde{p}_{ij}(a) = \tau_{ij} \tilde{p}_i(a)$.

2.3 Export Decision

Firms choose to export if it profits. The export revenue is expressed by:

$$R_{ij}(a) = p_{ij}(a, q) x_{ij}(a, q) = \left(\tilde{p}_{ij}(a) \tau_{ij}\right)^{1-\sigma} \tilde{P}_j^{\sigma-1} E_j \quad (1)$$

$x_{ij}(a, q)$ is the physical quantity consumed by *ROW* and $\{\tilde{P}_j, E_j\}$ are the price and expenditure of *ROW*. Revenue is a function of the quality and its relationship with $\{c, q\}$ depends on q/c . With the markup pricing, export revenue net of variable production costs is $\frac{1}{\sigma} R_{ij}(a)$. Then, firms export when the following condition holds:

$$\frac{1}{\sigma} R_{ij}(a) \geq f_{ij} \quad (2)$$

There exists a marginal firm with a threshold price $\tilde{p}_{ij}$ such that equation (2) holds with equality. Specifically:

$$\tilde{p}_{ij} = \frac{\tilde{P}_j}{\tau_{ij}} \left(\frac{E_j}{\sigma f_{ij}} \right)^{1/(\sigma-1)} \quad (3)$$

We define the corresponding capability threshold as a_{ij} :

$$a_{ij} = \frac{\sigma}{\sigma - 1} \frac{1}{A_i} \frac{\tau_{ij}}{\tilde{P}_j} \left(\frac{\sigma f_{ij}}{E_j} \right)^{1/(\sigma-1)} \quad (4)$$

Export revenue and export behavior depends on whether the manufacturer has a low quality-adjusted price or high capacity. Given fixed costs, only when the market competition is low (high $\tilde{P}_j$), the market size is large (large E_j), or when the trade cost is low (small τ_{ij}), exporters can obtain higher returns and manufacturers with lower capabilities are more likely to export. It is noted that both the fixed cost of market entry and trade cost affect the export threshold, which in turn affect the number of exporters and total bilateral exports.

To obtain the total export value, additional restrictions are placed on the relationship between cost, quality and capacity. The firm's quality is assumed to be a monotonic, constant elastic function of capacity: $q = a^\phi$, where ϕ is the elasticity factor of quality and capacity. Through this assumption, the heterogeneity of the manufacturer is reduced to a single dimension. And we can get the monotonic relationship between firm price and capacity and scale. Price can be expressed as $p_i(a) = \frac{\sigma}{\sigma - 1} \frac{Q_i}{A_i} a^{\phi-1}$,

and quality-adjusted price can be expressed as $\tilde{p}_i(a) = \left(\frac{\sigma}{\sigma - 1} \right) \frac{1}{A_i a}$.

Since firm revenue is a power function of capacity, if capacity follows the Pareto distribution, then sales in each market are Pareto. Suppose that the capacity obeys a truncated Pareto distribution,

the cumulative distribution function is $G(a) = \frac{a_L^{-k} - a^{-k}}{a_L^{-k} - a_H^{-k}}$, support $a \in [a_L, a_H]$ and the shape parameter k is restricted to $k > \max\{(\sigma - 1), (\sigma - \phi)\}$. The capacity distribution of all regions is assumed to be the same. Since there are also differences in regional capabilities, such an assumption retains capability differences. Sum up the revenue of all manufacturers exporting to ROW in region i to get the bilateral export value EX_{ij} :

$$EX_{ij} = \int_{a_{ij}}^{a_H} R_{ij}(a) N_i dG(a) = N_i R_{ij}(a_H) \bar{V}_{ij} \quad (5)$$

$R_{ij}(a_H)$ is the export revenue of the most capable manufacturers, which is positively related to the regional capacity A_i . The impact of endogenous export thresholds on total exports is quantified by $\bar{V}_{ij} = \int_{a_{ij}}^{a_H} (a / a_H)^{\sigma-1} dG(a)$. The aggregate exports are proportional to the exports of the most capable manufacturers. EX_{ij} can be further expressed as:

$$EX_{ij} = N_i \left[\tilde{p}_i(a_H)^{1-\sigma} \tau_{ij}^{1-\sigma} \tilde{P}_j^{\sigma-1} E_j \right] \left[\frac{k}{\delta_1} \left(\frac{a_{ij}}{a_H} \right)^{-\delta_1} - 1 \right] \quad (6)$$

$\delta_1 = k - (\sigma - 1) > 0$ means that the aggregate exports are negatively related to the export threshold and trade costs.

2.4 The Impact of Cross-Border E-Commerce

The CBEC platform is one of the ways for manufacturers to export to *ROW*. Different from the traditional way, the entry costs and trade costs via CBEC are lower. In terms of CBEC, the fixed entry cost is $e_i f_{ij}$ and the trade cost is $e_i \tau_{ij}$, where e_i ($0 < e_i \leq 1$) represents the development of the cross-border e-commerce platform in region i . For simplification, it is assumed that CBEC has the same impact on entry costs and trade costs. The more mature the CBEC platform in region i is, the more integrated the trade links are and smaller e_i is. A smaller e_i means that CBEC reduces trade costs more. To export via CBEC, the manufacturer needs to pay an additional fixed cost O_i ($O_i > 0$) of registering on the CBEC platform to obtain a virtual store and the basic services provided by the platform.

Manufacturers choose to export using either traditional methods or CBEC platforms. Looking back at (4), to export in the traditional international trade mode, the capacity of the manufacturer

needs to meet $a \geq a_{ij} = \frac{\sigma}{\sigma-1} \frac{1}{A_i} \frac{\tau_{ij}}{\tilde{P}_j} \left(\frac{\sigma f_{ij}}{E_j} \right)^{1/(\sigma-1)}$, and the net profit of the exporter is:

$$\pi_{ij}(a) = \frac{1}{\sigma} \left(\tilde{p}_i(a) \tau_{ij} \right)^{1-\sigma} \tilde{P}_j^{\sigma-1} E_j - f_{ij} \quad (7)$$

Exporting through CBEC platforms, revenue net of variable production costs is:

$$\frac{1}{\sigma} R'_{ij}(a) = \frac{1}{\sigma} \left(\tilde{p}_i(a) e_i \tau_{ij} \right)^{1-\sigma} \tilde{P}_j^{\sigma-1} E_j \quad (8)$$

If the export profit is positive, firms will export via CBEC platforms, specifically:

$$\frac{1}{\sigma} R'_{ij}(a) = \frac{1}{\sigma} \left(\tilde{p}_i(a) e_i \tau_{ij} \right)^{1-\sigma} \tilde{P}_j^{\sigma-1} E_j \geq e_i f_{ij} + O_i \quad (9)$$

We can derive the capability threshold of CBEC exporters a'_{ij} as:

$$a'_{ij} = \frac{\sigma}{\sigma-1} \frac{1}{A_i} \frac{e_i \tau_{ij}}{\tilde{P}_j} \left(\frac{\sigma}{E_j} \right)^{1/(\sigma-1)} \left(e_i f_{ij} + O_i \right)^{1/(\sigma-1)} \quad (10)$$

To explore whether CBEC lowers the export threshold, we compare a_{ij} with a'_{ij} . It turns out to compare $\frac{a_{ij}}{a'_{ij}} = \frac{1}{e_i} \frac{f_{ij}^{1/(\sigma-1)}}{\left(e_i f_{ij} + O_i \right)^{1/(\sigma-1)}}$ with 1. When $0 < O_i < e_i f_{ij} \left(\frac{1}{e_i^\sigma} - 1 \right)$, the export threshold for CBEC is lower. When $O_i = e_i f_{ij} \left(\frac{1}{e_i^\sigma} - 1 \right)$, the two thresholds are the same. When $O_i > e_i f_{ij} \left(\frac{1}{e_i^\sigma} - 1 \right)$, the export threshold for CBEC is even higher. The lower the CBEC registration cost (O_i), the lower the relative export threshold for CBEC. The greater the reduction effect of CBEC on trade costs (smaller e_i), the lower the relative export threshold for CBEC. In the case of $0 < O_i < e_i f_{ij} \left(\frac{1}{e_i^\sigma} - 1 \right)$,

companies with a capacity a between a'_{ij} and a_{ij} could not make a profit by exporting in a traditional way, while they could obtain a positive profit by exporting through CBEC. Therefore, these firms would export through CBEC. Cross-border e-commerce increases the proportion of exporters, allowing greater differences in capabilities, which reflects the inclusive characteristics of CBEC.

Assuming that $0 < O_i < e_i f_{ij} (\frac{1}{e_i^\sigma} - 1)$ is satisfied, firms with a capacity $a \in [a'_{ij}, a_{ij})$ export via CBEC. To analyze whether exporters with a capacity $a \in [a_{ij}, a_H]$ switch from traditional to CBEC exporters, we compare profits of the two choices. Since these firms are already exporters, the current profit is $\frac{1}{\sigma} (\tilde{p}_i(a) \tau_{ij})^{1-\sigma} \tilde{P}_j^{\sigma-1} E_j$. If they turn to CBEC, they need to pay a new fixed cost, and their profit is $\frac{1}{\sigma} (\tilde{p}_i(a) e_i \tau_{ij})^{1-\sigma} \tilde{P}_j^{\sigma-1} E_j - (e_i f_{ij} + O_i)$. Because $\frac{1}{\sigma} (\tilde{p}_i(a_{ij}) \tau_{ij})^{1-\sigma} \tilde{P}_j^{\sigma-1} E_j = f_{ij}$, we can analyze the marginal firm of the traditional exporters and derive the necessary condition on O_i for all incumbent exporters to switch to CBEC. That is:

$$\left[\frac{1}{\sigma} (\tilde{p}_i(a) e_i \tau_{ij})^{1-\sigma} \tilde{P}_j^{\sigma-1} E_j - (e_i f_{ij} + O_i) \right] - \frac{1}{\sigma} (\tilde{p}_i(a) \tau_{ij})^{1-\sigma} \tilde{P}_j^{\sigma-1} E_j > 0 \quad (11)$$

The above question can also be expressed in:

$$(e_i^{1-\sigma} - e_i - 1) f_{ij} - O_i > 0 \quad (12)$$

If $O_i < (e_i^{1-\sigma} - e_i - 1) f_{ij} = e_i f_{ij} (\frac{1}{e_i^\sigma} - 1) - f_{ij}$, the marginal firm of the traditional exporters will adopt the CBEC way, indicating all exporters will export via CBEC platforms. When $e_i^{\sigma-1} (1 + e_i) < 1$, $O_i < (e_i^{1-\sigma} - e_i - 1) f_{ij}$ also satisfies $O_i > 0$.

If $(e_i^{1-\sigma} - e_i - 1) f_{ij} < O_i < e_i f_{ij} (\frac{1}{e_i^\sigma} - 1)$, only some exporters with high enough capacity will turn to CBEC. To obtain the range of capabilities of these firms, we need to further compare the corresponding profits in the two cases. The analysis shows that when the firm's capabilities meet the following conditions, switching from traditional exports to CBEC is more profitable:

$$a > a''_{ij} = \frac{\sigma^{\frac{\sigma}{\sigma-1}} \tau_{ij}}{\sigma - 1} \tilde{P}_j^{\frac{1}{\sigma-1}} E_j^{\frac{1}{\sigma-1}} \left(\frac{e_i f_{ij} + O_i}{e_i^{1-\sigma} - 1} \right)^{\frac{1}{\sigma-1}} \quad (13)$$

and the firms with $a \in [a_{ij}, a''_{ij}]$ will maintain the traditional way of exporting. If the threshold for switching from traditional exports to CBEC (a''_{ij}) is greater than the upper limit of the regional capacity interval (a_H), except for the new exporters who enter the foreign market via CBEC, existing exporters maintain the traditional way.

In summary, as long as the CBEC platform registration costs(O_i) and the development of the CBEC platform(e_i) meet $0 < O_i < e_i f_{ij} (\frac{1}{e_i^\sigma} - 1)$, CBEC can reduce the export capability threshold.

Further, if $(e_i^{1-\sigma} - e_i - 1)f_{ij} < O_i < e_i f_{ij} (\frac{1}{e_i^\sigma} - 1)$ holds, the new exporters ($a \in [a'_{ij}, a_{ij}]$) adopt CBEC, existing exporters with the capacity $a \in [a''_{ij}, a_H]$ switch from traditional exports to CBEC, and exporters with medium capacity ($a \in [a_{ij}, a''_{ij}]$) adhere to the traditional way. It means that firms near the two endpoints benefit more from CBEC, and the inclusiveness of CBEC is not monotonous. If $O_i < (e_i^{1-\sigma} - e_i - 1)f_{ij}$ and $e_i^{\sigma-1}(1 + e_i) < 1$, that is, the values of O_i and e_i are small enough, all existing exporters and new exporters adopt CBEC.

Regarding the rationality of this prerequisite $0 < O_i < e_i f_{ij} (\frac{1}{e_i^\sigma} - 1)$, we find that the establishment of this condition means that $O_i + e_i f_{ij} < e_i^{1-\sigma} f_{ij}$, with $e_i^{1-\sigma} f_{ij} > f_{ij}$, it means that the fixed cost of CBEC ($O_i + e_i f_{ij}$) is not necessarily lower than the fixed cost of traditional exports(f_{ij}). In other words, the conditions that CBEC needs to meet to reduce the export threshold are not very harsh. In practice, the existence of CBEC exports can also prove the condition is met.

When $(e_i^{1-\sigma} - e_i - 1)f_{ij} < O_i < e_i f_{ij} (\frac{1}{e_i^\sigma} - 1)$, the aggregate export consists of CBEC export and traditional export, specifically:

$$EX'_{ij} = N_i R_{ij}(a_{ij}) \int_{a'_{ij}}^{a_{ij}} \left(\frac{a}{a_{ij}} \right)^{\sigma-1} dG(a) + N_i R_{ij}(a''_{ij}) \int_{a_{ij}}^{a''_{ij}} \left(\frac{a}{a''_{ij}} \right)^{\sigma-1} dG(a) + N_i R_{ij}(a_H) \int_{a''_{ij}}^{a_H} \left(\frac{a}{a_H} \right)^{\sigma-1} dG(a) \quad (14)$$

The change in aggregate export brought by CBEC is:

$$EX'_{ij} - EX_{ij} = N_i \left(\frac{\sigma}{\sigma-1} \right)^{1-\sigma} A_i^{\sigma-1} \tau_{ij}^{1-\sigma} \tilde{P}_j^{\sigma-1} E_j \left[e_i^{1-\sigma} \int_{a_{ij}}^{a_{ij}} a^{\sigma-1} dG(a) + (e_i^{1-\sigma} - 1) \int_{a'_{ij}}^{a''_{ij}} a^{\sigma-1} dG(a) \right] \quad (15)$$

The change in export threshold:

$$a_{ij} - a'_{ij} = \frac{\sigma}{\sigma-1} \frac{\tau_{ij}}{A_i \tilde{P}_j} \left(\frac{\sigma}{E_j} \right)^{\frac{1}{\sigma-1}} f_{ij}^{\frac{1}{\sigma-1}} \left(1 - \left(e_i + \frac{O_i}{f_{ij}} \right)^{\frac{1}{\sigma-1}} \right)$$

is positively related to entry costs f_{ij} and trade costs τ_{ij} , while it is negatively related to the region-specific capability A_i . After the emergence of the CBEC approach, the export threshold in regions

with a low A_i declines even more, and more exporters enter the market. On the other hand, the lower the region-specific capability, the higher the threshold for switching from traditional exports to CBEC, and the smaller the increase in trade brought by the transition. Briefly, the region-specific capability has two opposite effects on the increase in trade brought by CBEC. Hence, regional export growth can converge or diverge.

Based on the above analysis, the impact of CBEC on growth and convergence is summarized below. Convergence requires that the initial level of the variable is negatively correlated with its change. The emergence of CBEC has undoubtedly made a positive contribution to the growth of regional exports, but in terms of the growth trend, cross-border e-commerce may promote either the realization of convergence or divergence.

3. EMPIRICAL ANALYSIS

3.1 Regression Model

In the real world, different regions not only vary in capital stocks, but they also differ in terms of technology growth and labor growth. The conditions for σ convergence and absolute β convergence are difficult to meet. Therefore, this paper analyzes the conditional β convergence.

To test whether CBEC can promote regional economic growth and convergence, this paper adds the CBEC variables and the interaction terms with lagged output to the conditional β convergence estimation equation of Sala-i-Martin (1996). We estimate the following equation by fixed-effect models and systematic GMM methods:

$$Dy_{it} = \beta_0 + \beta_1 y_{i,t-1} + \beta_2 CBEC_{it} + \beta_3 y_{i,t-1} \cdot CBEC_{it} + BX + \mu_i + v_t + \varepsilon_{it} \quad (16)$$

i and t denote the province and year respectively, μ_i is the province fixed effect, v_t is the year fixed effect and ε_{it} is the error term. Dy_{it} is the change of the outcome variable y_{it} and $y_{i,t-1}$ is the lagged variable. $CBEC_{it}$ measures the development of CBEC in region i in year t and $y_{i,t-1} \cdot CBEC_{it}$ is the interaction term of CBEC and the lagged outcome variable. If β_1 is significantly below zero, it means there exists conditional convergence of y_{it} . If β_3 is significantly below zero, the marginal effect of $y_{i,t-1}$ conditional on a positive $CBEC_{it}$ is stronger than β_1 , indicating that $CBEC_{it}$ promotes the convergence of y_{it} .

Measures of the development of CBEC comprise of $CBEC_H_{it}$ and $cbec_zone_{it} \cdot CBEC_H_{it}$. $CBEC_H_{it}$ is a dummy variable about CBEC. It equals one when the number of CBEC exporters in province i in year t is in the upper tertile of the sample. Because the number of CBEC exporters in different provinces varies greatly, as small as only one and as large as more than 40,000, it is difficult to interpret the economic implications of coefficients when utilizing the level value or logarithmic value of CBEC exporters. Moreover, the empirical analysis of this paper is carried out at the provincial level. When the number of CBEC exporters in a province is small, it can hardly affect the economic growth of the province. Based on the tertile of the sample, the provinces are divided into “CBEC mature provinces” ($CBEC_H_{it}=1$) with highly developed CBEC exports and “CBEC breeding provinces” ($CBEC_H_{it}=0$), which distinguishes the development of CBEC between provinces and can better reflect the impact of CBEC on the economy. The reason why the second tertile is used instead of the median as in most literature is that the second tertile 1,077 is much closer to the majority of the number of CBEC exporters in CBEC developed provinces than the median 712.5, meanwhile, the variation of the sample is also considered.

cbe_zone_{it} is the number of CBEC pilot zones in province i as of year t . Within our data range, the latest batch of CBEC pilot zones was set up in July 2018. Considering the lag-effect of the policy, and to ensure sufficient ex-post observations, we limit the number of CBEC pilot zones to the first half of 2018.

Let $\ln gdp_{it}$ be the outcome variable y_{it} , (16) becomes the basic equation of this paper:

$$D \ln gdp_{it} = \beta_0 + \beta_1 \ln gdp_{i,t-1} + \beta_2 CBEC_{it} + \beta_3 \ln gdp_{i,t-1} \cdot CBEC_{it} + BX + \mu_i + v_t + \varepsilon_{it} \quad (17)$$

$D \ln gdp_{it}$ is the change of the logarithmic of real output per capita of a province in two consecutive years, and $\ln gdp_{i,t-1}$ is the logarithm of the real output per capita of a province in the previous year. The real output is adjusted according to the GDP index with 2000 as the base year. $\ln gdp_{i,t-1} \cdot CBEC_{it}$ is the corresponding interaction term. If conditional β convergence exists in China's economic growth, β_1 will be significantly negative. If CBEC can promote economic growth, β_2 will be significantly positive. If the development of CBEC can promote economic convergence, β_3 will be significantly negative.

X represents a series of control variables, including population growth rate, human capital growth rate, capital growth rate, lag of export dependence, e-commerce support index, e-commerce penetration index, lag of infrastructure and so on.

Change in population growth rate Dn_{it} is used as a proxy variable for labor growth rate, to reflect the impact of changes in labor input.

The growth of human capital $D \ln h_{it}$ measures the change in the logarithmic value of regional human capital. Human capital affects the ability of R&D and the ability to imitate and absorb advanced technologies from other regions. It influences the benefit from knowledge spillovers of technologically backward regions. We measure human capital by the average number of years of education of the population aged six and over.

Capital growth $D \ln k_{it}$ measures the change in the logarithm of capital per capita. Capital accumulation is one of the sources of economic growth. As the marginal output of capital diminishes, capital convergence is one of the mechanisms of economic convergence. We use the perpetual inventory method to estimate the actual capital stock with the base year of 2000 and calculates the actual capital per capita.

The lag of export dependence $export_{i,t-1}$ is the percentage of the export value in total output. It measures the degree of opening up. To alleviate endogenous problems, the lagged term is used. Exports expand market access, which is conducive to firm profits and capital accumulation.

The e-commerce support index ec_sup_{it} reflects the support of the environment in the development of e-commerce, including the basic environment, logistics, and human capital. The development of e-commerce requires the support of network infrastructure, e-commerce talents, and a convenient, reliable, and developed logistics environment. The requisite environment for CBEC includes, but is not limited to the conditions for e-commerce. The institutional support required for CBEC is almost the same across China, so the e-commerce support index is used as a proxy for the CBEC support index.

The e-commerce penetration index ec_pen_{it} reflects the impact of e-commerce on traditional economic activities. It comprehensively considers the impact of e-commerce on the supply side and the consumer side. Specifically, it is composed of three indicators: the ratio of enterprises with e-commerce activities to the total number of enterprises, the proportion of online buyers to the Internet

users and the proportion of online retail sales to the total retail sales of consumer goods. Considering the similarity, we use the e-commerce support index as a proxy.

Computer use density $\ln com_{it}$ is the logarithm of the number of computers used by every 100 employees. This variable reflects the degree of enterprise informatization and the basic environment for enterprises to use e-commerce and CBEC.

The lagged term of infrastructure $\ln road_{i,t-1}$ is a first-order lag term for the logarithmic value of the highway density in each province. Infrastructure is necessary for economic development and supportive for the development of CBEC. At the same time, economic growth may affect the investment and construction of infrastructure and therefore a lagged term is used.

Inter-provincial trade potential indicator $iptpi_{it}$ measures the potential of each province's trade with other provinces, constructed referring to the "Inter-provincial trade potential". Due to the lack of inter-provincial trade data, the inter-provincial trade potential indicator is constructed.

The development of the private economy $private_{it}$ is the ranking of the development of the private economy. The higher the ranking, the more developed the non-state-owned economy. Marketization as an institutional factor indirectly affects economic growth by affecting the efficiency of resource allocation and labor productivity.

3.2 Data

The sample is a panel data from 31 provinces in China (excluding Hong Kong, Macau, and Taiwan) from 2015 to 2018. The data on total factor productivity growth is only from 2014 to 2017. The descriptive statistics of the main variables are shown in Table 1. The mean VIF of the main variables is 2.74, which indicates there is no serious multicollinearity problem in the regression.

The number of CBEC exporters is from registered exporters in each province on Alibaba International Station. If the number of CBEC exporters in province i in year t is greater than or equal to the second tertile of the number of export merchants, the value is 1. Launched in 1999, Alibaba International Station is the largest domestic and also the world's leading international trade and overseas B2B cross-border trade platform. Therefore, the number of registered exporters on the Alibaba International website is very representative, and because the variable utilizes the number of exporters rather than sales, endogeneity may be avoided to some extent.

The details of the establishment of CBEC pilot zones are based on documents issued by the State Council of China¹. The first batch of establishments in March 2015 only includes Hangzhou, Zhejiang

Table 1. Descriptive Statistics of Main Variables

Variables	Obs.	Mean	Std. dev.	Min.	Median	Max.
Growth rate of output per capita	155	0.067	0.015	-0.024	0.068	0.101
Logarithm of output per capita	186	1.218	0.451	0.229	1.113	2.319
Number of CBEC pilot zones	186	0.199	0.474	0.000	0.000	2.000
Number of CBEC exporters	124	3494.202	7963.790	1.000	712.500	44406.000
Dummy variable of CBEC exporters	186	0.226	0.419	0.000	0.000	1.000
Export dependence	186	6.300	10.759	0.162	2.092	63.084
Growth of TFP	155	0.985	0.030	0.905	0.986	1.093

Province, and the second batch of 12 cities established in January 2016 covers 11 provincial regions, the third batch of 22 cities established in July 2018 covers 20 provincial regions. $cbec_zone_{it}$ is the number of CBEC pilot zones in province i as of July t .

The e-commerce support index and e-commerce penetration index are from the “China E-Commerce Development Index Report”. This report evaluates the e-commerce development indexes of each province in China, including e-commerce scale index, growth index, penetration index and support index.

The ranking of the development of non-state-owned economies comes from “China’s Marketization Index Report by Province (2018)”. From 2008 to 2016, the scores of non-state-owned economic development indexes in 31 provinces all improved, but the scores of eastern provinces are still significantly higher than those of other regions. The scores of several western provinces have been at the bottom, and the ranking of the 31 provinces has not changed much. Since the data is only updated to 2016, to ensure the sample size, the ranking of non-state-owned economic development in 2016 is used as the ranking for 2017 and 2018 to extend the data to 2018.

The number of years of education per capita that measures human capital is based on the education structure of the population in the statistical yearbooks of the provinces. The education years corresponding to each education stage are weighted to obtain the average years of education. The treatment of the number of years of education in 2015-2018 is based on 16 years of undergraduate and above education, 15 years, 12 years, 9 years, 6 years, and 0 years of college education, high school, junior high school, primary school, and illiteracy. For years of education before 2015, college education and above are counted as 15 years instead.

Hong and Guo(2012) constructs the “regional market size (market potential function)” indicator and the “inter-provincial trade potential” indicator. It is calculated as $iptpi_{it} = \left(\sum_{j \neq i} Retail_{jt} / D_{ji} \right) / GDP_{it}$,

where $Retail_{jt}$ is the total retail sales of consumer goods in provinces other than i , D_{ji} is the distance between the capitals of provinces i and j , and GDP_{it} is the output of i in t . The total retail sales of consumer goods come from the National Bureau of Statistics of China. The distance between capitals is the spherical distance calculated based on the latitude and longitude of capitals.

We select 9.6% as the capital depreciation rate of each province and calculate the actual capital stock based on 2000. Considering the small sample size of panel data in China’s provinces, this paper uses data envelopment analysis to estimate the total factor productivity. We use DEAP 2.1 software for calculation. The calculation process requires actual total output, actual capital stock, and the labor force in each province. The labor input data is from the statistical yearbooks of provinces.

The population from 2014 to 2018 comes from the China Statistical Yearbook (2015-2019 edition). The nominal GDP, GDP index, export value, annual average exchange rate, and highway mileage of each province in China are from the National Bureau of Statistics of China. Based on this, the real GDP per capita based on 2000, the export value in Renminbi, export dependence, and highway density are calculated.

Based on the sample data, we draw a scatter plot and a linear fitted graph of the output value and export value, as shown in Figure 1. The vertical axis is the change of the corresponding variable $D.\ln gdp$ or $D.export$. The axis is the corresponding lagged term $L.\ln gdp$ or $L.export$. All the linear fitted lines in the figure are sloped downward, but the slopes and intercepts are slightly different. Based on this, it can be roughly judged that regardless of the number of CBEC pilot zones or CBEC exporters, the growth of output and export volume has shown a trend of β convergence.

Figure 1. Scatter and fitted line of output

Figure 2. Scatter and fitted line of export

3.3 Results

3.3.1 Baseline Results

We use a fixed-effect model to estimate equation (17) and obtain the results shown in Table 2. Columns (1) and (2) are the results using the number of CBEC pilot zones to measure CBEC, (3) and (4) are the results using the dummy of CBEC exporters. We add other control variables in (2) and (4).

The lagged $\ln GDP$ is significantly negative, indicating the conditional β convergence exists in China's regional economic growth. In the second estimation, the coefficients of the CBEC pilot zones are significantly positive and the interaction terms are significantly negative, which means the establishment of the CBEC pilot zone has a significant positive impact on economic growth and the convergence. In (3) and (4), holding other factors equal, the economic growth rate of CBEC-mature provinces is significantly higher than in other provinces. The interaction term is significantly negative, which means CBEC has a stronger role in promoting economic growth in provinces with lower per capita GDP. In other words, the results in Table 2 show that CBEC promotes economic convergence in China.

3.3.2 Robustness Check

To test whether geospatial effects affect the conclusions of the previous section, we introduce the inter-provincial trade potential index as a control variable. Comparing Table 2 (2) and Table 3 (1), Table 2 (4) and Table 3 (3), we can find that ignoring the geospatial effect makes the effect of CBEC on economic growth overestimated. Except that the difference between provinces with one CBEC pilot zone and those without CBEC pilot zones becomes insignificant, the significance of other CBEC variables remain unchanged.

The degree of marketization is considered as an important institutional factor affecting economic development. To test whether the development of non-state-owned economic affects the conclusions above, the development of the private economy is introduced. In the model, the impact of the private economy on economic growth is insignificant, and the estimated coefficients of CBEC and the interaction terms have not changed significantly, indicating the effects of CBEC are independent of the development of private economy.

To mitigate the influences of economic fluctuations, the average annual growth rate of per capita GDP for three consecutive years is used as the explanatory variable instead. Accordingly, the first-order lagged term of per capita GDP in the explanatory variables is changed to the second-order one. The growth of per capita GDP still has a trend of conditional convergence. Cross-border e-commerce measured by CBEC pilot zones and CBEC exporters still has a significant role in promoting economic growth, showing the robustness of the results.

Although the use of the dummy variable for the number of CBEC exporters will not incur reverse causality, the establishment of the CBEC pilot zones is not randomly determined, and the addition of control variables cannot rule out endogeneity perfectly.

To further solve the endogeneity, we use the systematic GMM method for estimation. We introduce the first-order lagged term of the explained variable in the equation, and uses lagged terms of the potential endogenous variables including CBEC and the interaction term as instrumental variables. The estimated results are shown in Table 4. Without adding control variables, the economic growth of CBEC-breeding provinces has a divergent trend, and the CBEC-mature provinces tend to converge. In the system GMM estimation results, the convergence trend of economic growth is weaker, and the role of CBEC is also weaker.

We use Arellano-Bond autoregressive tests AR (1) and AR (2) to test whether the difference terms of the error term have first-order autocorrelation and second-order autocorrelation. The validity of GMM requires there is no second-order or higher-order autocorrelation in the difference term of the error term. The p-value of the AR (1) test is less than 0.2, and the p-value of the AR (2) test is

Table 2. Baseline results

	(1)	(2)	(3)	(4)
L.lngdp	-0.1871***	-0.3661***	-0.2883***	-0.3378***
	(0.035)	(0.109)	(0.059)	(0.096)
1.cbec_zone	0.0076	0.0234*		
	(0.010)	(0.013)		
2.cbec_zone	0.0615	0.1702*		
	(0.046)	(0.087)		
1.cbec_zone*L.lngdp	-0.0084	-0.0218**		
	(0.007)	(0.010)		
2.cbec_zone*L.lngdp	-0.0408	-0.1192**		
	(0.028)	(0.055)		
CBEC_H			0.0291	0.0354*
			(0.019)	(0.021)
CBEC_H*L.lngdp			-0.0234**	-0.0255**
			(0.011)	(0.012)
D.lnk		0.0016		0.0021
		(0.001)		(0.001)
D.n		-0.3453		-0.2464
		(0.356)		(0.278)
D.lnh		0.0427*		0.0304
		(0.024)		(0.025)
L.ec_pen		0.0002*		0.0001
		(0.000)		(0.000)
ec_sup		-0.0007		-0.0003
		(0.001)		(0.001)
Incom		-0.0381*		-0.0557**
		(0.020)		(0.026)
L.export		-0.0005		0.0001
		(0.000)		(0.000)
L.lnroad		-0.0693		-0.0784
		(0.131)		(0.114)
Constant	0.2700***	0.6524***	0.3939***	0.6692***
	(0.037)	(0.169)	(0.066)	(0.180)
Province FE and year FE	yes	yes	yes	yes
Obs.	155	124	124	124
R²	0.346	0.456	0.354	0.424

Note: 1.cbec_zone equals one when there is one CBEC pilot zone in the province, otherwise it is zero. 2.cbec_zone is defined in the same way. The robust standard errors are in brackets. ***, **, and * indicate the significance at 1, 5 and 10% level, respectively. The following tables are the same.

Table 3. Robustness check

	(1)	(2)	(3)	(4)	(5)	(6)
	$\ln gdp_{it} - \ln gdp_{i,t-1}$				$(\ln gdp_{it} - \ln gdp_{i,t-2}) / 2$	
L.lngdp	-0.3877***	-0.3655***	-0.3670***	-0.3374***	-0.3022***	-0.2689***
	(0.103)	(0.113)	(0.090)	(0.102)	(0.050)	(0.047)
1.cbec_zone	0.0158	0.0228			0.0130	
	(0.013)	(0.014)			(0.011)	
2.cbec_zone	0.1551*	0.1695*			0.1044**	
	(0.081)	(0.093)			(0.047)	
1.cbec_zone	-0.0153	-0.0215*			-0.0148	
*L.lngdp	(0.010)	(0.011)			(0.009)	
2.cbec_zone	-0.1051*	-0.1189**			-0.0786**	
*L.lngdp	(0.052)	(0.057)			(0.031)	
CBEC_H			0.0326*	0.0354*		0.0263*
			(0.018)	(0.021)		(0.014)
CBEC_H			-0.0232**	-0.0255**		-0.0217**
*L.lngdp			(0.011)	(0.012)		(0.008)
iptpi	-0.0303**		-0.0325**			
	(0.013)		(0.012)			
private		0.0001		0.0001		
		(0.001)		(0.001)		
constant	0.7334***	0.6503***	0.7576***	0.6685***	0.4745***	0.4929***
	(0.152)	(0.180)	(0.164)	(0.190)	(0.092)	(0.111)
Province FE and year FE	yes	yes	yes	yes	yes	yes
Obs.	124	124	124	124	124	124
R²	0.554	0.456	0.540	0.424	0.592	0.572

Note: "L.lngdp" in columns (1) to (4) represents the first-order lag term of $\ln gdp$, and it represents the second-order lag term in columns (5) and (6)

large. We perform the Hansen J test and the p-values are much larger than 0.1, which indicates the instrumental variables are jointly effective.

We also use the average number of telephones(ph) from 1984 to 1989 as an instrumental variable for CBEC to further prove the robustness. The prevalence of telephony in various provinces before 1989 is much earlier than the sample period, and it can hardly affect the economic growth rate of the sample period, which makes the variables meet the exogenous requirements of instrumental variables.

Table 4. Robustness check: GMM

	(1)	(2)	(3)	(4)
L.dlngdp	0.5972***	0.1815*	0.7597***	0.5741***
	(0.066)	(0.108)	(0.111)	(0.125)
L.lngdp	-0.0070	0.0105	0.0121*	-0.0178
	(0.009)	(0.013)	(0.007)	(0.017)
1.cbec_zone	0.0016	0.0396*		
	(0.009)	(0.024)		
2.cbec_zone	0.1785**	0.1498		
	(0.071)	(0.131)		
1.cbec_zone*L.lngdp	-0.0003	-0.0290*		
	(0.008)	(0.015)		
2.cbec_zone*L.lngdp	-0.1063**	-0.0977		
	(0.042)	(0.075)		
CBEC_H			0.0150**	-0.0148
			(0.007)	(0.014)
CBEC_H*L.lngdp			-0.0128*	0.0132
			(0.007)	(0.013)
constant	0.0327**	0.0371	0.0000	0.0285
	(0.013)	(0.037)	(0.000)	(0.031)
Control variables	no	yes	no	yes
Obs.	124	124	124	124
AR(1) test	0.123	0.161	0.112	0.148
AR(2) test	0.450	0.976	0.448	0.502
Hansen J test	0.909	0.771	0.457	0.999

Secondly, the telephone and the Internet are both communication methods, and there are common factors that need to be considered in the promotion and line laying of various places. The areas that popularized the telephone earlier may access Internet broadband and other facilities earlier when the Internet appeared. Therefore, this variable meets the relevance requirements.

To ensure the endogeneity of the number, we use historical data as early as possible. In practice, since the province's historical average number of telephones ph does not change with time, the interaction terms of year dummies and ph are used as instrumental variables for CBEC. Moreover, in the first stage of estimation, the endogenous variables $CBEC_H$ and $CBEC_H * L.ln gdp$ have weak correlations with instrumental variables. To avoid biases caused by weak instrumental variables, the logarithm of the number of CBEC exporters $\ln CBEC$ is used instead. To make the endogenous variables exactly identified, the dummy variable $cbec_zd$ of CBEC pilot zones is used instead of the exact numbers. If the number of CBEC pilot zones is positive, $cbec_zd$ equals one, otherwise zero.

The results are shown in Table 5. The first two columns are the results of regressions of endogenous variables to instrumental variables in the first stage, and the third column shows the result of the second stage estimation of the instrumental variable method. The results of

Table 5. Robustness check: iv

	(1)	(2)	(3)	(4)	(5)	(6)
	first	first	second	first	first	second
	lnCBEC	lnCBEC *L.lngdp	dlngdp	cbec_zd	cbec_zd *L.lngdp	dlngdp
L.lngdp	27.465	3.016	-0.312***	28.070*	40.689*	-0.296***
	(16.915)	(14.998)	(0.077)	(14.341)	(21.442)	(0.062)
2015.year*ph	-0.808**	-0.487*		-0.524**	-0.668*	
	(0.321)	(0.285)		(0.262)	(0.391)	
2016.year*ph	-0.536**	-0.335*		-0.311*	-0.451*	
	(0.217)	(0.193)		(0.176)	(0.264)	
2017.year*ph	-0.230**	-0.201*		-0.152	-0.222	
	(0.133)	(0.118)		(0.107)	(0.161)	
2015.year*ph	-1.966	0.631		-2.235*	-3.253*	
*L.lngdp	(1.373)	(1.217)		(1.163)	(1.738)	
2016.year*ph	-1.989	0.630		-2.202*	-3.171*	
*L.lngdp	(1.375)	(1.219)		(1.163)	(1.739)	
2017.year*ph	-2.016	0.631		-2.202*	-3.169*	
*L.lngdp	(1.376)	(1.220)		(1.163)	(1.739)	
2018.year*ph	-2.027	0.625		-2.201*	-3.166*	
*L.lngdp	(1.377)	(1.221)		(1.164)	(1.740)	
CBEC			0.046***			0.091*
			(0.015)			(0.047)
CBEC*L.lngdp			-0.011*			-0.051**
			(0.006)			(0.024)
constant	11.513**	-0.269	0.227**	4.976	6.323	0.401***
	(4.961)	(4.399)	(0.096)	(3.028)	(4.527)	(0.069)
Obs.	124	124	124	124	124	124
R²	0.405	0.942		0.516	0.606	
Province FE and Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Hausman test			0.201			0.843

the first stage show the instrumental variables meet the condition of correlation. The results of the second stage show a tendency for economic convergence. The application of CBEC has significantly promoted economic growth and convergence, which is consistent with the basic conclusion of the previous section. The p-values of the Hausman test are all greater than 0.2, and the null hypothesis that all explanatory variables are exogenous cannot be rejected. Therefore, the estimated results of the fixed-effect model are almost the same as those of the instrumental variable method.

3.3.3 Heterogeneity

The differences in economic development between the eastern and mid-western regions may affect the effects of CBEC on the regional economy. Therefore, we compare the effects in eastern and mid-western regions. The dummy variable *east* is used to distinguish between the eastern and mid-western provinces. The eastern provinces include Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan, a total of 11 provinces and cities.

As shown in Table 6, the output of the eastern region converged faster, but the significance of the difference is unstable. The interaction term of the CBEC pilot zone and the region dummy variable *east* is insignificant, indicating there is no significant difference in the effects of the CBEC pilot zones on the economic growth of eastern and mid-western provinces. The interaction term of the CBEC pilot zone, the dummy variable *east*, and the lagged output reflects the difference in the influence of CBEC pilot zones on economic convergence in the east and mid-west. The results show that compared with the mid-western regions, the eastern provinces with one CBEC pilot zone have divergent economic growth, but the difference becomes insignificant after adding control variables. It means that the difference in the impact of convergence is related to differences in the economic level, openness, and e-commerce infrastructure in eastern and mid-western provinces, which reflects that to realize the potential policy effect requires the cooperation of local basic conditions.

In the two columns to the right of Table 6, the interaction term of CBEC and the regional dummy is significantly negative, indicating the promotion effect of CBEC on mid-western economic growth is greater than that of eastern provinces. The interaction term of CBEC, the regional dummy variable, and lagged output is significantly positive, meaning that compared to the mid-west, CBEC promotes the divergence of economic growth in eastern provinces. At this time, the differences in the effects are significant before and after controlling other variables. In other words, besides differences in input factors, economic levels, and export levels between eastern and mid-western provinces, other omitted variables make the two regions benefit differently from CBEC. Productivity differences are one of the possible factors. There is a large gap in productivity between the eastern and mid-western regions, while there is no significant difference between the central and western regions. According to equations (14) and (15), the higher the regional capacity, the smaller the decline in the export threshold caused by CBEC, and the greater the increase in the aggregate regional exports. The application of CBEC has brought a greater impact on the export threshold of low-productivity mid-western provinces, promoted the diversification of export entities, strengthened economic and technological exchanges, and had a stronger driving effect on economic growth. However, after the application of the CBEC platform in the eastern region, the export value increased even more. After a series of transmissions, cross-border e-commerce promotes the development of economic growth in a divergent direction.

3.3.4 Mechanisms

This section first examines the impact of CBEC on exports, and then examines the changes in export dependence, export value, and the deviation of export volume. From the estimation results in Table 7, it can be seen that the growth of export dependence, export value, and export value deviation tend to converge. Provinces with two CBEC pilot zones have a slower convergence in export dependence, but their export value has converged faster, and the deviation of export values has contracted faster. There is no significant difference between the exports of CBEC-mature provinces and other provinces, but the convergence of the export dependence of CBEC-mature provinces is slower than that of other provinces, which also reflects CBEC is a driving power of export dependence.

In comparison, CBEC pilot zones have a stronger role in promoting the convergence of regional export than the CBEC platform. The establishment of CBEC pilot zones aims to promote the formation of a new pattern of comprehensive opening up. Its establishment is accompanied by simplification of logistics, warehousing, customs clearance and other processes in the pilot zones, as well as innovation

Table 6. Heterogeneity in the east and mid-west

	(1)	(2)	(3)	(4)
	cbec_zone		CBEC_H	
L.lngdp	-0.1986***	-0.3784***	-0.3126***	-0.3679***
	(0.056)	(0.126)	(0.060)	(0.093)
east*L.lngdp	0.0068	-0.0321	-0.1212***	-0.1383***
	(0.025)	(0.039)	(0.041)	(0.031)
1.cbec_zone	0.0344**	0.0365		
	(0.013)	(0.022)		
2.cbec_zone	0.0814	0.1376		
	(0.062)	(0.105)		
1.cbec_zone*L.lngdp	-0.0296**	-0.0323		
	(0.011)	(0.022)		
2.cbec_zone*L.lngdp	-0.0541	-0.0996		
	(0.039)	(0.065)		
east*CBEC	-0.0649	-0.0493	-0.2345***	-0.2406***
	(0.045)	(0.037)	(0.083)	(0.066)
east*CBEC*L.lngdp	0.0406*	0.0309	0.0846*	0.0863**
	(0.023)	(0.023)	(0.042)	(0.036)
CBEC_H			-0.0292	-0.0266
			(0.022)	(0.022)
CBEC_H*L.lngdp			0.0284	0.0284
			(0.019)	(0.019)
constant	0.2784***	0.6950***	0.5091***	0.8202***
	(0.058)	(0.221)	(0.081)	(0.200)
Control variables	no	yes	no	yes
Province FE and year FE	yes	yes	yes	yes
Obs.	155	124	124	124
R²	0.364	0.470	0.416	0.492

in the supervision. The improvements create a favorable environment for the development of CBEC, and reduce the time and costs of CBEC exports. However, the number of CBEC exporters reflects the results of the optimal choice of operating entities. The breadth and depth of the CBEC platform's influence are relatively limited.

Next, we test whether CBEC affects economic growth indirectly through regional inputs. As shown in Table 8, the growth of human capital and labor tends to converge, while the growth of capital has no significant convergence trend. The population growth rate of provinces with two CBEC pilot zones is significantly higher than that of other provinces. The population growth of these provinces also tends to converge. With the similar birth rate and mortality rate, the difference in population growth rate reflects the difference in net population inflows. The establishment of CBEC pilot zones has attracted population inflows, and has a greater effect on provinces with lower population

Table 7. Mechanism: export

	(1)	(2)	(3)	(4)	(5)	(6)
	Export dependence	Export value	Export value deviation	Export dependence	Export value	Export value deviation
L.export	-0.4720***	-0.4268***	-0.5294***	-0.9537***	-0.6169***	-0.7299***
	(0.024)	(0.067)	(0.062)	(0.009)	(0.089)	(0.067)
1. L.cbcc_zone	-0.2320	-0.1050	-0.1070			
	(0.232)	(0.142)	(0.073)			
2. L.cbcc_zone	-1.1141	0.7779**	0.0720			
	(0.802)	(0.365)	(0.129)			
1. L.cbcc_zone	0.1394	0.0223	0.0301			
*L.export	(0.149)	(0.016)	(0.020)			
2. L.cbcc_zone	0.2747***	-0.0897**	-0.0547**			
*L.export	(0.055)	(0.034)	(0.022)			
L.CBEC_H				-0.0531	0.1204	0.0128
				(0.116)	(0.135)	(0.068)
L.CBEC_H				0.0995*	-0.0052	-0.0115
*L.export				(0.049)	(0.015)	(0.016)
constant	6.9435***	3.2257***	0.5922***	1.4406***	2.6411***	0.9268***
	(1.017)	(0.497)	(0.080)	(0.131)	(0.660)	(0.087)
Province FE and year FE	yes	yes	yes	yes	yes	yes
Obs.	155	155	155	124	124	124
R²	0.716	0.954	0.373	1.000	0.963	0.434

Note: For parsimony, *L.export* in the regressions of columns (2) and (5) refers to the first-order lagged term of the export value, and in columns (3) and (6) it refers to the first-order lagged term of the export value deviation.

growth rates, contributing to balancing the distribution of labor resources. Among the three inputs, the convergence of human capital is the most significant, while the convergence of human capital growth in CBEC-mature provinces is slightly slower. This may be because CBEC export has higher requirements for talents and a greater demand for highly educated personnel and promotes manpower from the demand side. However, neither CBEC pilot zones nor CBEC exporters show significant promotion or hindrance to the convergence of physical capital.

Finally, we examine the impact of CBEC on changes in total factor productivity. As shown in Table 9, the higher the lagged output, the lower the change of total factor productivity (*tfpch*), the change of technical efficiency (*effch*), and the change of pure technical efficiency (*pech*). The impact of lagged output on technological change (*techch*) is positive, but not robust. The CBEC pilot zone has a significant positive impact on the changes in total factor productivity, technical efficiency, scale efficiency, and technology change, and the growth of these variables in the provinces with lower output is even stronger. Among them, the CBEC pilot zone promotes the convergence of efficiency by promoting the convergence of scale efficiency, which means it advances the shrinking of the difference between the production scale of the enterprise and its optimal production scale. The promotion effect on the convergence of technology means that CBEC enables economically backward provinces to have higher technology growth rates, pushing them to catch up with the leading provinces.

Table 8. Mechanism: input factors

	(1)	(2)	(3)	(4)	(5)	(6)
	D.lnh	D.lnk	D.n	D.lnh	D.lnk	D.n
L.y	-0.6108***	-0.1484	-0.3843***	-0.9772***	-0.4488	-0.5876***
	(0.080)	(0.177)	(0.134)	(0.042)	(0.388)	(0.142)
1.L.cbec_zone	-0.1140	0.0440	0.0023			
	(0.072)	(0.052)	(0.002)			
2.L.cbec_zone	0.1723	-0.5009	0.0069***			
	(0.116)	(0.571)	(0.002)			
1.L.cbec_zone*L.y	0.0469	0.0111	-0.4959			
	(0.032)	(0.026)	(0.304)			
2.L.cbec_zone*L.y	-0.0813	0.2271	-0.3607***			
	(0.052)	(0.244)	(0.131)			
L.CBEC_H				-0.1652***	-0.2595	0.0027
				(0.048)	(0.247)	(0.003)
L.CBEC_H*L.y				0.0705***	0.1210	-0.1293
				(0.020)	(0.104)	(0.287)
constant	1.3231***	0.4663	0.0024***	2.1399***	1.2137	0.0040***
	(0.179)	(0.421)	(0.001)	(0.090)	(0.980)	(0.001)
Province FE and year FE	yes	yes	yes	yes	yes	yes
Obs.	155	155	155	124	124	124
R²	0.429	0.083	0.403	0.746	0.075	0.494

Different from the impact of the CBEC pilot zone, the total factor productivity growth of CBEC-mature provinces is significantly higher than that of others, but the growth of its decomposition variables shows no significant differences. CBEC exports have a stronger role in boosting total factor productivity, pure technical efficiency, and technological change in provinces with lower per capita output. The use of the CBEC platform has an impact on the company's structure and operation, enabling the company to improve its production efficiency at the current technology level. Also, it provides enterprises with access to more advanced technologies and knowledge, accelerating technological progress. Cross-border e-commerce exports help to gradually reduce the productivity gap between economically backward regions and developed regions, speeding up economic convergence.

4. CONCLUSION, SUGGESTIONS AND RESEARCH PROSPECTS

We use panel data from 31 provincial regions in China from 2015 to 2018. The number of CBEC exporters and the number of CBEC pilot zones are exploited as proxy variables for the application of CBEC. The basic conclusion is that CBEC promotes economic growth and economic convergence in China. We also find that there is no significant difference in the promotion effect of CBEC on the economic growth of eastern and mid-western provinces, but CBEC weakens the trend of economic convergence in eastern China.

Table 9. Mechanism: tfp

	(1)	(2)	(3)	(4)	(5)
	tfpch	effch	pech	sech	techch
panel a: cbec_zone					
L.lngdp	-0.2853***	-0.3566***	-0.3580***	-0.0045	0.0771*
	(0.059)	(0.045)	(0.052)	(0.032)	(0.040)
1L.cbec_zone	0.0416***	0.0202	-0.0081	0.0287*	0.0209*
	(0.007)	(0.014)	(0.008)	(0.015)	(0.010)
2L.cbec_zone	0.1550***	0.1358***	0.0043	0.1618***	0.0038
	(0.032)	(0.030)	(0.037)	(0.035)	(0.020)
1L.cbec_zone*L.lngdp	-0.0328***	-0.0192**	-0.0030	-0.0166*	-0.0133**
	(0.004)	(0.008)	(0.003)	(0.009)	(0.006)
2L.cbec_zone*L.lngdp	-0.1005***	-0.0880***	-0.0161	-0.0904***	-0.0030
	(0.021)	(0.020)	(0.026)	(0.023)	(0.012)
constant	1.2716***	1.3352***	1.3558***	0.9852***	0.9308***
	(0.062)	(0.047)	(0.055)	(0.035)	(0.042)
Province FE and year FE	yes	yes	yes	yes	yes
Obs.	124	124	124	124	124
R²	0.660	0.520	0.263	0.037	0.608
panel b: CBEC_H					
L.lngdp	-0.2420**	-0.2590**	-0.3115***	0.0430	0.0247
	(0.112)	(0.113)	(0.111)	(0.046)	(0.022)
L.CBEC_H	0.0224***	0.0036	-0.0019	0.0045	0.0189
	(0.008)	(0.017)	(0.007)	(0.013)	(0.012)
L.CBEC_H*L.lngdp	-0.0194***	-0.0064	-0.0069*	0.0011	-0.0131*
	(0.005)	(0.010)	(0.004)	(0.008)	(0.007)
constant	1.2542***	1.2622***	1.3384***	0.9351***	0.9837***
	(0.125)	(0.126)	(0.125)	(0.052)	(0.025)
Province FE and year FE	yes	yes	yes	yes	yes
Obs.	93	93	93	93	93
R²	0.631	0.371	0.233	0.023	0.832

This paper has the following theoretical contributions: first, this paper constructs a theoretical model on the impact of CBEC on regional participation in international trade, and finds it is possible for the emergence of CBEC to promote the convergence or divergence of regional export. Second, this paper elaborates the mechanism of CBEC on economic growth. Specifically, regarding the mechanism of CBEC on economic growth, this paper has the following findings: First, CBEC promotes the narrowing of differences in the inter-provincial development of international trade. Secondly, CBEC promotes the convergence of labor input and the divergence of human capital growth, but does not affect the growth of physical capital. Third, CBEC advances the economically backward regions to

catch up with the productivity of the leading regions, and has a positive impact on the convergence of the growth of pure technological efficiency and technology change.

Based on the discovery that the development of CBEC exports contributes to the convergence of regional economic growth, to reduce the regional economic gap in China, the policy suggestions are as follows.

The first is to promote the construction of infrastructure conducive to the development of CBEC in economically backward areas. The second is to accelerate the spread of the successful and reproducible experience accumulated in CBEC comprehensive pilot zones to other regions, especially in less developed regions of CBEC. China has set up comprehensive pilot zones for CBEC in cities with a good basic environment to conduct first-come, first-test and achieved remarkable outcomes.

Although this paper has tried to explain the impact of CBEC on economic convergence as far as possible, there are still some defects in empirical research due to data availability. Therefore, the future research directions are as follows: first, on the basis of updating the macro data, considering the development of CBEC after 2018. On the one hand, after 2018, CBEC has received more policy support. In December 2019 and April 2020, the State Council added two batches of CBEC comprehensive pilot zones, with a total of 105 CBEC comprehensive pilot zones. Also, the COVID-19 has caused an important impact on the economic development of provinces and CBEC enterprises, which is an important test for discussing the impact of CBEC in the future. Second, on the basis of obtaining enough micro data, this paper discusses the differences between cross-border e-commerce enterprises and traditional foreign trade enterprises in micro enterprise behavior, such as investment behavior or export decision-making behavior, and finally obtains the complete logic chain of cross-border e-commerce influencing macroeconomic development.

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ENDNOTE

- ¹ Announcement on the establishment of the first batch of cross border e-commerce comprehensive pilot zones http://www.gov.cn/zhengce/content/2015-03/12/content_9522.htm, Announcement of the second batch of establishment, http://www.gov.cn/zhengce/content/2016-01/15/content_10605.htm, Announcement of the third batch of establishment, http://www.gov.cn/zhengce/content/2018-08/07/content_5312300.htm

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