Technological Change and Decision of Make-or-Buy in Developing Economy

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Abstract

This paper aims to investigate the effect of technological change on manufacturing decisions in the surgical manufacturing Industry of Pakistan. The research was concentrated on three manufacturing decisions, outsourcing (International), in-house manufacturing, and both (in-house/International). This paper used multinomial logistic regression to investigate the set of relationships with categorical outcome variables (Manufacturing Decisions), using a set of data composed of 115 firms. Technological change factors and non-technological factors as control variables (Firm Age, Firm Size, and Human Capital), the paper provides causal evidence of how advanced technology increases the outsourcing probability. This strategy will help the firm avoid incurring the sunk cost on their investment when a new technology is introduced. The sunk cost is even higher when a firm produces at a small scale and is mitigated by other high-scale producers in the market. Therefore, the increased scale producers to which other low-scale producers outsource their production should be manufactured products prone to technological changes. The governments may extend their integration within the global economy and diversify exports from merchandise to value-added presentations and services. Considering the technological changes and, most significantly, offer economy-wide developmental advantages in terms of increased employment ratios and a higher standard of living while adopting technological changes. A firm faces the challenge of producing a specific product internally or purchasing it from a specialized vendor. The findings also suggest that firms outsource products prone to rapid technological advancement. It will benefit the industry where technological changes are frequent.

Keywords: outsourcing, technological advancement, make-or-buy

Introduction

In much of economic research, the emphasis is on the decision of "make-or-buy"(Coase, 1937). Williamson (1971, 1985, 1998) explains that inadequate contracts and specificity of assets play critical roles in the

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decision of make-or-buy in his transaction cost theory (Sarwar et al., 2020). Moreover, the property rights theory explains the investment dependence related to the good final producer on the incentives to integrate/outsource. This dependency is shown to have a relatively significant joint relationship to succeed (Gibbons, 2005; S. J. Grossman & Hart, 1986).

Technology is changing rapidly every day. This decides whether to outsource to go for in-house production, even complex because today's technology will likely be obsolete soon. One solution to this problem is outsourcing, which means purchasing products, parts, or components from suppliers already bearing the cost of employing the latest technology (Rehman et al., 2020). The recent trend in outsourcing is the result of such alternatives. Most economists believe in outsourcing as a worthy business approach because it expands potency, reduces cost, accelerates development, and allows firms in the global market to mark their "core competencies." In most cases, this indeed is true. Outsourcing has facilitated US firms in offsetting the harmful and damaging powers of globalization, i.e., strengthening competition and associated value and profit erosion (Houseman, 2007).

Problem Statement

Introducing new technology (equipment and material) will undoubtedly allow the firms to decrease the production cost of certain products. However, this decision depends on the intensity of the equipment and material used because the installation cost of new equipment becomes sunk cost for the firm. Thus, the firm will only employ new equipment if its usage justifies paying the cost that comes with it. This decision will also depend upon the firm's production scale and the interval for which the technology (equipment) will be employed. This paper focuses on how the change in technology impacts the decision of make-or-buy by the firms. Previous literature on technological change and outsourcing by firms focuses on the significance of the potency of technology that results from spillovers in R&D (Bartel et al., 2005). Our approach is different as we consider the influence of technological change on a firm's outsourcing decision.

Literature Review

Tadelis (2007), in his study, inquired that what is traditionally called the "make or buy" decision can also be viewed as a "buy or buy" decision? For example, when a carpenter decides whether to purchase a specialized nail from a seller or produce it himself depends upon buying and managing the inputs required to make the specialized nail. Thus it can

be called the "buy or buy" decision. Besanko et al. (2007) observed that specialized suppliers provide their services to many firms at a time. This leads to a higher production of the product than the individual production services (Khan et al., 2021). The specialized vendor will have a cost advantage because of lower per-unit cost leading to economies of scale. Ramarapu et al. (1997) explained this by considering the benefits of outsourcing, and some producers still prefer in-house manufacturing because of the fear of losing control over product design and its production process. Therefore, only the firms with lower production cost will find it ideal to outsource.

In earlier studies, Nelson & Winter, (1982) noticed that the decision to adopt new technology for a firm is not an easy task. Although new technology enhances production techniques and outcomes, lowering the per unit cost also imposes the new cost of installing equipment on the firm, which becomes a sunk cost. Hence, introducing technology is entrenched in the capital (equipment) utilized to manufacture specific output. New difficulties highlighted by Abramovsky et al., (2006) shows that while considering the decision of employing new technology, a firm must rely on the size of the market for those specific products. This consideration allows the vendors to adopt new technology more efficiently. As compared to the firms that purchase them, vendors can spread the sunk cost over more customers as reported by Chongvilaivan & Thangavelu, (2013).

Bartel et al., (2005) concluded that technological change in production increases the outsourcing by firms. The decision of "buy-or-buy" for a firm depends on three alternatives: producing with the existing (old) technology already available to approach vendors for outsourcing and employing new technology by investing in new equipment. As discussed earlier, the vendor has the benefit of high-level production as compared to an individual firm. Besides, the vendor, due to investing in the latest technology, can produce at a lower cost and offer their products at a lower price. These two advantages that a vendor has over an individual firm allows the firm to begin outsourcing.

Kohler et al., (2009) featured in their study that new technology employed will get obsolete after a period, but the sunk cost of upgrading to this new technology will still be incurred. Therefore, the number of firms that are not adopting new technology will increase. These firms will begin outsourcing as the pace of new technology rises. Outsourcing will be more profitable for firms rather than in-house production. The rate at which new technology reaches the markets affects the "buy-or-make" decision. It also determines the time needed for further investment in the latest technology installed in the firm. The pace at which new technology

is introduced to the market affects how a firm must pay off the sunk cost. As compared to individual firms, it is easier for a vendor to amortize the cost of employing new technology because they capture a more significant portion of the market. Their customers also benefit from avoiding the sunk cost by transacting with the vendors, which is confirmed by Rana & Ghani, (2004).

This paper used the firm-level data obtained through the field survey of SIMI, Pakistan. This study uses the multinomial logistic regression (mlogit) analysis. This paper analyses how technological change can influence the make and buy decision. Previous literature highlights various variables that lead to outsourcing. This paper attempts to assess whether our findings align with previous literature in the presence of technological changes (Panezai et al., 2021). Furthermore, this paper aims at determining the significance of non-technology variables of outsourcing like firm size, firm age and human capital, considering previous literature (see Abraham & Taylor, 1996; Autor, 2001; Díaz-mora & Triguero, 2006; Görg & Girma, 2003; Holl, 2004).

Research Gap

A very few recent econometric studies have begun to explicitly look at the link between organizations and outsourcing (Zhao & Li, 1997; Harvie et al., 2010; Srinivasan & Archana, 2011). At international level several studies report that the characteristics of firms vary widely within industries in determining the outsourcing decision (Capasso *et al.*,2013; Tomiura, 2005; 2008; and Wignaraja, 2002; 2012; 2013 ;2014). Firms which are involved in exports or outsourcing are more prone to technological change, larger, more efficient, and have higher levels of skills than other firms. The notion of firm heterogeneity receives broad support from empirical work.

At national level very, few studies looked at the link between the technological change and outsourcing decision. Whereas many studies while highlighting the issues in SIMI of Pakistan, ignored the emergence and need of outsourcing within global supply chains to overcome the issues prevailing in SIMI specially to explore the export potential in industry (Nadvi & Halder, 2002; 2005; Rana & Ghani, 2004; Bhutta, 2006; Rehman *et al.*, 2014 and Ikram *et al.*, 2016). Our study attempts to remedy these gaps in the empirical literature, covering the Surgical instrument industry of Pakistan with technological and non-technological factors to determine outsourcing decision.

Conceptual Framework

This study's framework is parallel to Stigler (1951). He discusses the link between vertical integration and the industry's size and concerns that a young (infant) industry needs material and technology that is new. Therefore, they are forced into manufacturing their specialized products. The industry continues to grow until a certain point at which it gets profitable to specialize in a specific product (Fazal et al., 2021). Hence, the sector integrates vertically. This view supports the idea of the presence of variables that are nor associated with technology. The number of approaches to technological capabilities and national innovation systems highlighted by Bell & Pavitt (1993), Iammarino et al. (2008), Lall (1992), Wignaraja (2002) discloses a diverse network through which the behavior of a firm affects its export performance and manufacturing decision. Fundamental evolutionary theory of technological change by Nelson & Winter (1982) stress that complicated firm-level procedures and multifarious exchanges with organizations are desirable to engross imported technologies efficiently and professionally.

A basic equilibrium model of Outsourcing Decision is presented in this section. This model forms as per Grossman & Helpman (2002) 's instinct, fusing firm heterogeneity regarding differences in firm-level dimension factors, explicitly profitability. They pointed out that two conceptual frameworks can account for outsourcing decisions:

1. The first one is the theory of transaction costs developed by Coase (1937), which has dominated the theoretical literature on outsourcing decisions.
2. The other one fuses with the approach of core competencies towards outsourcing decisions, where the firm's competitiveness ascends from doing outsourcing decisions (Gainey & Klaas, 2003; Grant, 1991).

To summarize, outsourcing is not a profitable option for all firms. This model recommends that firms with higher productivity will, in general, go for outsourcing. Simultaneously, outsourcing decisions rely on some costs, i.e., transaction costs and efficiency gains related to such activities. Some firms should be suitably productive/efficient. A considerable production scale permits gains from a decrease in marginal costs to overwhelm the transaction costs and sunk cost caused due to adoption of technological change. Only then the outsourcing decision can be liberated as profitable.

H_1: The impact of technological change on production (in-house) is less in the case of both production (in-house & international).

H_2: The impact of technological change on production (international) outsourcing is stronger in the case of both production (in-house & international).

Data and Empirical Specifications

Surgical Instrument and Manufacturing Industry, Pakistan

The data was collected using the survey of Pakistan's Surgical Industry, Sialkot. The sample size was 115 companies/firms. For conducting a study, an online and telephonic contact has been managed through the officials (managers/CEOs/Directors) of the Surgical Instruments and Manufacturing Association of Pakistan (SIMAP). Further, the list of the registered firms/companies in the industry was provided by the SIMAP officials, which helped further the field survey. Whereas questions constructed were based on a Likert scale 1-5, Strongly Disagree, and 5 represent Strongly Agree. The scale was adapted from the past studies (Kraljević & Lacković,2020; Shapovalov, 2018; Terber et al., 2019; Titu et al., 2018). The data feed was done online through STATA and an Excel spreadsheet converted into a numerical form for modelling purpose.

Table 01
Categories for Manufacturing Decision

Category	Manufacturing Decision
1	In House production
2	Outsourcing (International)
3	Both

Descriptive Analysis

The descriptive statistics of the selected variables have been done to get a fundamental analysis of the study. The research aims to summarize variables so that the interactive pattern of the variables is provided for the study. An enhanced representation of sample and responses pie charts and frequency tables are calculated for each variable.

Variable Construction and Explanation

This industrial data set has a three-level variable called Manufacturing decision (coded 1, 2, 3) as the outcome variable. The predictor variables have technological change and three non-technological variables (human capital, firm size, and firm age), scaled on a Likert point scale. The scale validation is excess through Cronbach alpha and the main study variables shows the minimum threshold of 0.6 and 0.7 for the technological change (Hair et al., 2019).

The Manufacturing decision was designed using a question in the survey for the type of decision the firm is indulged in, i.e., outsourcing, in-

house or both (transform it into different values of 1, 2, 3). The final data shows that in the sample firms in Pakistan, 53.91% of firms outsource their manufacturing process, 27.83% go for in house manufacturing and 18.26% of firms do the combination of both.

Technological Change and Innovation

The rate at which technological change occurs, the questions used in this paper include information on firm-level like "research and development" and "process innovation". Both the variables are to be highly correlated to technological changes that the firm uses. Supposedly, the highly creative and innovative firms may opt for high engagement in research and development, process innovation, and product outsourcing.

In Section 2 of the questionnaire, the framework developed describes that the firm's outsourcing decision will be affected by its expectations. When a firm highly engages in Research and Development and process innovation, it is supposed to positively correlate the firm's expectation and the "Research and Development", and innovation processes used in the respective industry. A firm's operation and activities highly depend upon the patent it receives from the industry. Technological innovations positively correlate to firms export status (Hobday, 2001 and Wignaraja, 2012). Conscious efforts towards investments are required to enhance knowledge and skills for efficient technological operations rather than just building technical capabilities based on years of production experience. This hypothesis is similarly supported by qualitative indication built on direct interviews and secondary sources, arguing that modernization and efficiency remain connected to global outsourcing (Castellani & Zanfei, 2007).

Additional Controls for Non-Technological changes

Some of the non-technological factors (variables) are also controlled regarding the determination of outsourcing decision at the firm's level (Nazir & Mahmood, 2018). At first, the firm's size is controlled, allowing larger firms to benefit from economies of scale in production. Ono (2007) suggests another possibility of considering larger firms. He assumes that larger firms will prefer outsourcing when faced with fixed transaction cost. The transaction costs usually occur when the firm searches for compatible suppliers.

Secondly, the variable that measures the cost of the human capital of the firm's industry. Human Capital enhances an organization's export performance and is also one of the technological change results within a given activity. More elevated levels of human capital are, for the most part, connected to the advancement of more powerful corporate techniques

(Van Dijk, 2002). An educated staff comprised of secondary school graduates tends to be more profitable and versatile to the innovations than those who are not. Moreover, a CEO with the required degree or professional formulating and work experience may have a superior business state of mind (regarding hazard captivating or readiness to actualize new corporate thoughts).

Finally, knowledge and experience are related to innovation can also affect firms' decision to outsource. Thus, use the firm's age to assess the impact of a firm's expertise and knowledge on the manufacturing decision. The decision to outsource production or services is likely to be impacted by the knowledge and experience accumulated over a considerably higher period for old firms. First, the use of relatively modern technology by younger enterprises may increase productivity and enhance product quality (Van Dijk, 2002). Second, the eagerness and readiness to learn the recent business and technical opportunities in their production networks play a significant role. Keeping these prospects in view, we have also checked for these non-technological variables to strengthen our study.

Econometric Model

To establish a relationship between technological changes and manufacturing decisions, an econometric model is to be developed in empirical evidence. A Multinomial logit (Mlogit) model is used to determine the association between the independent variables and the likelihood of manufacturing decision of the firm activity. To do so, the following econometric description is to be considered by taking into consideration equation (3):

$$\Pr(MD_i = 0|\bar{\theta}_i, X_i) = \vartheta(\alpha + \beta\bar{\theta}_i + \gamma X_i) \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where $Pr(\bullet)$ is denoted as probability and $\vartheta(\bullet)$ is denoted as the cumulative distribution function (CDF). The multinomial variable of manufacturing decision (MD) is taken 0 if a firm i represents in house production; for outsourcing, it is accepted as one while it is taken as 2 in case of combination, i.e., in house and outsourcing, and $\bar{\theta}_{\mathrm{I}}$ represent the level of technological changes, whereas *xi* is a vector of all other non-technological changes.

In a multinomial logistic regression model, the outcome variable exceeds more than two levels. It guesses the likelihood of being at or under a definite outcome level provided several explanatory variables. To explain the probability of choice of a multinomial model is assumed that outsourcing can be reflected by all the firms that are included in the sample, a portion of their products in the house too, signifying a methodical classification of firms. It is to be emphasized that the cited econometric model (1) can also be perceived as a latent variable version

where a latent (unobserved) variable (MD) is regressed on the independent terms.

$$MD_i = \alpha + \beta\bar{\theta}_i + \gamma X_i + \varepsilon_i \quad \text{..... (2)}$$

where, $MD_i = \begin{cases} 1\ if\ MD_i > 0 \\ 2\ if\ MD_i < 0 \\ 3\ if\ MD_i = 0 \end{cases}$ And the error term ε_i is supposed to be independently and identically distributed.

Results and Discussion

Index Construction for Data Analysis

The index was constructed for each of the independent variables. World Bank opted to deal with the Likert scale in its report on women empowerment case study (House *et al.*, 2010). Each question was averaged after allotting the inverse of maximum scale value as weight. This restricts the index to range from 0 to 1. A zero indicates the respondent's minimum response, while one means the maximum response on the Likert scale.

Multinomial Logistic Regression

To model the nominal outcome of the variables, multinomial logistic regression is used. This regression allows modeling the outcomes as a linear arrangement of the independent variable. In the model, manufacturing decision (MD) is treated as an indicator variable, i.e., a categorical variable. The "base" option in State was used to show the category for the baseline group comparison. The below-stated model shows the selection of both (in-house and international) for the baseline category. The manufacturing decision (MD) below in table 02 has two categories as of the dependent variable. It represents two models estimated as In-House associated with Both and outsourcing relative to Both.

$$ln\left[\frac{p(MD=inhouse)}{p(MD=Both)}\right] = \beta_0 + \beta_1(TC) + \beta_2(FS) + \beta_3(HC) + \beta_4(FA)$$

..... (3)

$$ln\left[\frac{p(MD=outsource)}{p(MD=Both)}\right] = \beta_0 + \beta_1(TC) + \beta_2(FS) + \beta_3(HC) + \beta_4(FA)$$

..... (4)

Coefficient and Base Group

These refer to the coefficients and the base/referent level in the model estimated by multinomial logistic regression. Significantly, the multinomial logit model estimates the *k-1* models, where *k* is assumed to be the number of levels of the outcome variable. Therefore, Stata sets both

inhouse-Both (equation 3) as the base/referent category used to estimate the in-house production relative and model for Both.

Table 02
Multinomial Logistic Regression

) Manufact Decision (In-House)	β	S. E	t	p	[CI]		Dec
TC	-1.11	.53	-2.09	.036	-2.15	-.069	S
FS	2.31	.71	3.23	.001	.90	3.72	-
HC	.32	.72	0.45	.64	-1.08	1.74	-
FA	.57	.48	1.19	.23	-.36	1.51	-
Constant	-8.04	3.2	-2.46	.013	-14	-1.6	-
) Manufact Decision (Outsourcing)							
TC	1.43	.508	2.82	.004	.43	2.43	S
FS	-.103	.52	-0.20	.844	-1.13	.93	-
HC	2.04	.72	2.84	.004	.63	3.45	-
FA	.107	.43	0.25	.804	-.74	.96	-
Constant	-12	3.36	-3.81	.000	-19	-6.21	-
Pseudo R^2	0.2653						
χ^2	61.3196						
Prob > χ^2	0.000						

**** p<.01, ** p<.05, * p<.1, Manufact= Manufacturing, β= Path coefficients, S. E= standard error, t=t-statistics, p= significance, CI= Confidence Interval, Dec= Decision of hypothesis, and S= decision supported.*

Table 02 presents the results of multinomial logistic regression. Section A in table 02 shows the in-house manufacturing decision based on both types of manufacturing decisions. The Technology (TC) shows negative log-odd with in-house manufacturing decision. The change in the technology changes of the firm's Technology decrease in-house manufacturing decision with 1.11 log-odd of being preferring in-house manufacturing over both manufacturing decisions. Firm size (FS) is the sole significant variable that affects the in-house manufacturing decision. The increase in FS of the firm for in-house relative to both categories increases in-house manufacturing decision by log-odds of 2.31, preferring in-house over both. Human Capital (HC) and firm age (FA) show the positive log-odd, which is insignificant. The multinomial logit estimates for in-house relative to both categories show .32 and .57 with an

insignificant relationship, which shows that these two variables are not affecting the in-house manufacturing decision.

Table 02 (B) shows the outcome of multinomial logit estimates for outsourcing (international manufacturing decision). The study's primary variable, technological change (TC), shows a positive relationship with outsourcing manufacturing decision. If the firm's Technology increases by one unit, the log-odds estimate for preferring international manufacturing decision over both types of manufacturing decision would expectedly increase by 1.43 unit while keeping the other variables in the model constant. The result shows that technological change is a quite significant predictor for international manufacturing decision. Human capital is an essential predictor for international manufacturing decision. The significant positive relationship shows that human capital influence outsourcing by 2.04 log odd. The other control predictors FS and FA, show an insignificant relationship with outsourcing over both manufacturing decisions.

Results Discussion

Previous studies on make-or-buy decision focus on the significance of relationship-oriented investment in a scenario where some part of the contract becomes impossible to verify ex-post and, therefore, non-contractible ex-ante (Williamson, 1971, 1975, 1985; Grossman and Hart, 1986). The framework used in this study mainly focuses on the role of technological change in production, assuming full contractibility. The key findings of our empirical exercise can be summarized as follows.

Technological change is an essential component of outsourcing, and firms with high quality and innovative market segments are more prone to outsourcing (Kraljević & Lacković,2020). Technical Capabilities and Innovation plays a role in determining manufacturing decision; either domestic or international. Firms highly characterized by technology and technological change have a higher probability of outsourcing if they have both options. This result consistently aligns with the findings of (Bartel et al., 2009), who states that the pursuit of knowledge complementarities is one of the main factors of linkage recombination in the region (Shapovalov, 2018).

This study primarily focuses on how technological change affects outsourcing. It also provides evidence that non-technology factors (variables) also have an impact on the decision. Prior literature also highlights the importance of non-technology factors in outsourcing and its proper estimation (Wignaraja, 2014). The empirical assessment firstly highlighted for firm size found that larger firms outsource more production activities. Secondly, Human Capital is another outsourcing aspect in

Pakistan that is firm-specific among SIMI decision making processes (Terber et al., 2019). The results show a positive relationship between workers' education on a firm choosing internal and external manufacturing decisions as they have highly skilled laborers. Simultaneously, the ancillary parameters through the base category differentiated the coefficient of technological and non-technology variables for the adjacent level of MD. Concerning the base outcome, this study concluded that the SIMI firms used to outsource more than opting for in-house while combining both in-house and outsourcing. The impacts of technological and non-technological factors (Titu et al., 2018).

Conclusion and Policy Implications

Many researchers have emphasized how characteristics like incomplete contracts and specificity of assets affect a firm's decision to produce domestically (in-house) or opt for outsourcing. The findings suggest the inclusion of a complementary approach to addressing the make-or-buy decision by including some non-technology factors. The rate of technological change influences outsourcing decision by incorporating time length over which it is possible to harvest new technology. The results reveal that the firms are more likely to outsource than domestically producing when new technologies are rapidly appearing. It leads a firm to rely on large scale producers who can quickly alleviate the risk of sunk cost because they capture larger chunks of the market. Hence, it is beneficial for the firms to outsource and avoid the possibility of these sunk costs.

An investigation into industrial data depicts that SIMI plays an essential role in Pakistan's economic activity. SIMI is the major source of employment in Sialkot, Pakistan, but it also contributes notably to Pakistan's Gross Domestic Product (GDP). The results also suggest that firms that embrace the technological changes over time, larger firms with increasing age and a higher level of human capital are the leading players in SIMI that decide to outsource more while few of the firms go for the in-house production. Nonetheless, the available information also hints at a modest increase in outsourcing decisions by the share of SIMI exports.

Thus, this study's results are robust to different specifications, including a variable that helps in measuring each industry's proportional output against a "specific" input. The existing literature presents some non-technology factors like labour cost and capacity utilization and sales volatility. At the same time, findings suggest little evidence of such variables' effect when accounting for the firm's fixed control variables. Furthermore, our results impose that outsourcing of products is attractive when they are characterized by technological change.

Some policy implications can be drawn from the above and group discussion with CEOs of SIMI. First, Asian countries with growing or emerging economies strategically enhance their contribution towards GSCs as part of their export-oriented growth methods that incorporated related policies for industry, trade, and investment (in the shape of technological change). The government should take initiatives to extend their integration within the global economy, diversification of exports from the merchandise to value-added productions and services. Considering the technological changes and, most significantly, offer economy-wide developmental advantages in terms of increased employment ratios and a higher standard of living while adopting technological changes.

While businesses are progressively adopting new technological functionalities, human capital is and will always be vastly superior to the impact of digital transformation. Therefore, regardless of the magnitude of technical advancement, it is even more critical for human resources participating in outsourcing operations to invest in individual, team, and organizational professional development. Subtasks include restructuring the range of products and determining vertical integration. Additionally, manpower, technology, and pattern management are considered. The approach deliberately avoids sophisticated optimization models. It satisfies practitioners' desire for simple-to-use decision support by proposing a straightforward scenario-based generation and evaluation of potential reallocations. The strategy was successfully used to a company that manufactures medical devices.

Lastly, to encourage development policy and technological advancement to be the main factor for outsourcing/offshoring, national statistics must assess growth and trade trends. Significant government's incentives fuse using a consistent definition of outsourcing, so to empower better mapping of the firm's exports, endeavoring to include the part of indirect exports into gross export data, and eventually, estimating the value-addition in trade.

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