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The CPEC Supply Web Framework in Context of Modern Manufacturing

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ABSTRACT

There is a need to understand and integrate the technologies and concepts of the 4th industrial revolution (Industry 4.0), supply chain management, modern manufacturing and the opportunities provided by the logistic and development programs of Belt Road Initiative (BRI) and China Pakistan Economic Corridor (CPEC). The knowledge of multiple fields such as industry 4.0, supply chain management, logistic supply chain management and CPEC project plans have been synthesized. An attempt has been made to model a future state created through CPEC facilities and initiatives. A model framework is presented based on the core infrastructure of CPEC projects, which will push Pakistan towards industrialization through utilizing modern manufacturing techniques and establishment of supply web. The CPEC supply web model proposes to create high quality, mass customized products from raw material and parts to be supplied from local and nearby regions through efficient logistic pathway of CPEC and BRI. A supply chain operational reference (SCOR) model has also been developed for an insight into the scenario. It is important for investors, trade associations, businessmen and policy makers to understand the population, market, and economic dynamics along with modern manufacturing trends to create smart factories and supply chains in context of CPEC. The lessons learned from the planning, development and application of the solutions presented by CPEC can be utilized by other regions and countries depending on their relevant unique geostrategic and economic perspectives.

Keywords: CPEC; Industry 4.0; smart factory; supply chain; logistics management

INTRODUCTION

It is necessary for policy makers and business developers to understand the history and future of manufacturing. There is also a need to observe the ancient trade routes and study the pathways being developed for future logistics. The gateways to Central Asia and China will be opened by China Pakistan Economic Corridor (CPEC). The drastic changes in logistics infrastructure as well as other development projects are all geared to improve the life, economics and welfare of millions of individuals (Abid and Ashfaq 2015). All logistic infrastructures are geared to enhance trade and ultimately create factories for manufacturing products. The concept of creating a smart, autonomous, flexible, robotic and self-managed factory is the ultimate goal of industry 4.0. The ability of mass customization and to interconnect through the supply web across countries, entities, businesses and factories is also a goal (Ustundag and Cevikcan 2017). CPEC was envisioned to create a modern supply web across the Central Asian countries, China and Sub-Continent region. The sources of power generation in the form of hydro, coal and renewable energy resources are being developed under CPEC in Pakistan. Internet connectivity is to be improved through new internet cables and improved transmission. The roads, railways, ports and airports developed will improve the physical logistics connections. The high populations of Pakistan, India, China and Iran and the rich regions of Central Asia, having vast resource, all indicate the possibility for generating high economic activity in the region. The belt and road initiative (BRI) and China Pakistan Economic Corridor are galvanizing the region (Butt et al. 2015; Christopher 2016). It is envisioned that these initiatives are to aid in manufacturing new products and items to be delivered across the supply web fulfilling the need of millions of people. An attempt has been made to integrate the history of trade and manufacturing with modern manufacturing trends. To gain maximum advantage from these modern factories, the industrial logistic supply chain needs to be developed which is going to be aided by CPEC and BRI programs. There is a need to understand and integrate the technologies, concepts of the 4th industrial revolution (industry 4.0), supply chain management, modern manufacturing and the opportunities provided by the logistic and development programs of BRI and CPEC. The modern theories, concepts and infrastructure planning for CPEC have been integrated to prepare a scenario for success and accelerated economic activity in the region for its population. The foundation stone for continuous success

TABLE 1. Summarized details of industrial revolutions

Revolution	Timespan	Trigger	Effect
Industry 1.0	1760-1840	Mechanization, steam power, weaving loom.	Mechanical production
Industry 2.0	1860- 1950	Mass production, assembly line, electrical energy.	Mass production
Industry 3.0	1960-2000	automation, computers, electronics, semi-conductors	Automation
Industry 4.0	2000	Cyber physical systems, internet of things, industrial networks, machine learning, sensors, internet	Smart technology, customization, supply chain integration

has been laid which is regularly being improved and refined by planners to ensure optimum profit.

LITERATURE REVIEW

HISTORY OF TRADE AND BUSINESS

The business of trading products is an ancient and noble profession. Historically, humans were concentrated in specific areas, civilizations, and villages. We can perhaps accept the fact that this isolation was more or less prevalent on the earth till the 18th Century. It was mostly the armies, traders, messengers and travelers who moved on the earth. The journeys were hard, tedious and in some instances meant not coming back home. The business of trade was carried out with the help of caravans by undertaking lengthy journeys. The craftsmen carried out their trade with the barter system as a means of exchange. The gold coins were the means of exchange later on (Maestro 1993). The craftsmen were solely responsible for the manufacture of the whole product with the artisan priding himself for the skill, intricacy and quality of the work. This product was unique, involving huge effort and time. The unique and quality local products were traded with other regions through trade routes (Sabel 1982). The British, French and Spanish all undertook exploration and discovered new colonies like America, Indian Subcontinent and South East Asia. Expanding trade, development of new markets and sourcing was one of the main reasons. The development of the sea routes took place in complement with land routes (Kearney 2004). In context of Subcontinent the Grand Trunk Road and Silk Road were important trade routes (Liu 2010, Sarkar 1927). The sea lane from Arab to South East Asia passed near Sindh, a part of the Sub Continent. Hence the ancient times had important trade routes in terms of both land and sea, which were the sources of connectivity between various regions (Sarkar 1927; Liu 2010; Kearney 2004).

THE INDUSTRIAL REVOLUTIONS

The initiating technology behind the industrial revolution was the steam engine. The source of power generation shifted from animals towards modern machinery. The middle of the 18th Century saw changes in industry with the development of wind mills and steam locomotives. The first industrial revolution changed the lifestyle of western societies. Technology advancements and machinations started to incorporate in daily life of human beings. The important concepts were the development of industries, scientific management, piece wage system for workers, mass production, interchangeable parts and standardization. Warfare technology was revolutionized through development of guns, muskets and rifles (Deane 1979). The second industrial revolution was initiated by the discovery of electricity. With electricity being a cheap and good source of power, the human and industrial norms were drastically changed. The period between 1860 till 1950 saw the development of new inventions, factories and ways of doing useful work. All important inventions like radio, bulb, aero plane, automobile, telegraph and internal combustion engines were initiated during this period (Mokyr 1998). The world wars greatly enhanced military research and expenditures. The personnel trained during the war effort, resources spent and new concepts developed were diverted towards the industrial sector after 1945. The expenditure on reviving industry and repairing the damage caused by war sustained the world economy (Milward 1984). Mass production started in factories with the Ford Plant being a pioneer in designing an assembly line for production. The driving competition, desire to improve quality and reduce costs while at the same time enhancing production was achieved through the development of computers, automation, numerical controlled machines and programmable logic controller (PLC) systems. These aspects initiated the third industrial revolution in 1960 – 1970 (Greenwood 1997). Modern industrial management practices, norms and techniques were developed (Stearns 2018, Groover 2007). A brief overview of the four industrial revolutions is presented in Table 1.

Human Beings are perhaps not fully aware of the massive changes which have taken place during the past 200 years. With electricity, locomotives, aircrafts, ships, telephones, cars, aero planes, computers, internet the trading patterns and the logistics involved have undergone a massive transformation. A message which took months to be delivered now takes seconds. The journey which took months in past, is now done in hours. Satellites, television, internet and cellular networks, all are playing a huge role. The machinery, technology, factories and modern products have been developed for the growing population of the world. These above mentioned factors, inventions and technologies have enabled the world to come closer, learn, trade and create wealth. The creation of much needed products also required effective management planning for mass production. Factories were created and the field of engineering management gave valuable guidance towards

planning for manufacturing. The development of new information technologies and powerful computing facilities have opened the avenue for the fourth industrial revolution. The driving technology behind the smart revolution is the internet of things, big data analytics, simulations, augmented reality, robotics, artificial intelligence, horizontal and vertical integration and additive manufacturing. These technologies will be having a drastic impact in the way we do industrial work, and also influence our lifestyle. There is a need to not only understand our past but explore the potential of the future ahead (Ustundag and Cevikcan 2017).

MASS PRODUCTION VS. MASS CUSTOMIZATION

One of the most distinguishing developments of the second industrial revolution was the ability of factories to mass produce standard products in high volumes. The age of craftsman, who completed the whole product gave way to division of labor, interchangeable parts, standardization and economies of scale. The modern assembly line with all its management aspects came into existence. With the demand for quality and modern products increasing for creating ease and comfort in life, mass producing factories came into existence. The focus during World War II was on mass production of tanks, airplanes, weapons and supplies which later shifted to other consumable goods afterwards. Ford greatly reduced the lead time of production through the assembly line arrangement (Williams et al. 1992). The increasingly better lifestyle, wealth and better standard of living fostered consumerism and development of modern factories (Christopher 2016, Groover 2007) (Hounshell 1985; Williams, Haslam, and Williams 1992).

With the advent of industry 4.0 there is a shift towards mass customization. To create variety, demand and customer fulfillment, industries are now focusing on customized products for the customer. However, these industries still retain the advantages of mass production leading towards the use of term mass customization (Gilmore and Pine 1997). An example is the production of customized footwear in the factory with each shoe being according to the specific foot print of the customer. Another example is the manufacture of custom made bikes according to the weight, height and physique of the customer. Modern technology enables automotive customers to choose various options to be fitted into the car according to need and requirement. Computer design, information technology (IT), modern machinery, quick changeover, handling of variety and online purchasing all enable the factory for mass production with customization (Ustundag and Cevikcan 2017; Radziwon et al. 2014).

FOCUSED FACTORY VS. SMART FACTORY

The concept of manufacturing plants is based on the focused factory. Leaders and Planners have recognized that it is not possible to produce complex units involving the transition from raw material to final product completely under one roof. The manufacturing plants rather focus on a few value adding transformation processes. These processes are unique and give a competitive advantage to the firm. These few activities are what the firm does best, serve needs of customer and create profits for the enterprise. During each decade of 20th century, new technologies and management philosophies have evolved and doing more with less resources has become the norm (Feld 2000). Planners have come to realize that the single large manufacturing enterprise cannot perform all of the manufacturing tasks of the product. The make or buy decision has become very important (Cánez, Platts, and Probert 2000). Non-core activities have been outsourced. Lean manufacturing has become the norm. The economics and profitability of each and every step is evaluated before being undertaken (Groover 2007; Ketokivi and Jokinen 2006; Pesch 1996).

The industry 4.0 technologies enable creation of an autonomous, flexible and smart factory which can handle new variety, volume and models of products. The industry 4.0 technologies are presented in Table 2. The smart factories consist of cyber physical systems, with modules capable of additive manufacturing. These modules are capable of conducting machine to machine communication. Smart machinery and smart products communicate and configure themselves for manufacturing in the smart factory. Machinery is self-optimized and configure for smart maintenance, machining and handling. These factories will require high connectivity, data storage, and qualified expert manpower. The modular cyber physical additive manufacturing units will be plugged to the main connecting line and mass customize to produce variety of units with various sizes and volumes.

All decision and monitoring is done in real time with big data analytics and artificial intelligence playing a vital part. Wastage is not only reduced but precise manufacturing is enabled by additive manufacturing and industrial robotics. The data is shared across the whole supply chain fostering better collaboration, communication and cohesiveness. Supply chain is integrated horizontally within company and vertically across all entities (Groover 2007, Ustundag and Cevikcan 2017, Lucke, Constantinescu, and Westkämper 2008).

LOGISTIC SUPPLY CHAIN MANAGEMENT

The manufacturing unit has shifted its boundaries from an internal focus to include external entities. This is achieved through arrangement of communication, information sharing, collaboration, trust and interdependence involving partners from the raw material supplier, secondary supplier, vendor to the distributor, retailer and customer. This arrangement in modern management is called supply chain (Chopra and Meindl 2007). The elements of supply chain management are listed in Table 3. It involves the flow of logistics through all units and entities, from creation of raw material to final product. Logistics management means the management of forward and reverse flow of products, finances and information. The elements of logistic supply chain management are presented in Table 4. Just as an army cannot survive without critical supplies such as food, ration,

water, fuel and ammunition, the flow of products, money and information is critical for the business survival. The disruptions, delay in supplies, breakdown, strike, shutdown and other reasons can have a disastrous cascading effect on all joined entities in the chain (Christopher 2016). The outsourcing of business functions allows businesses to focus only on the few value creating steps. Each business has a physical boundary perhaps, but it is increasingly becoming possible through information sharing, collaboration, joint efforts and supplier relationship management for businesses to come closer to each other. They understand each other's requirements and create effective supply chains which are completely visible to strategic planners, effective, responsive and above all provide monetary profits for all.

The phenomenon of revenue in a supply chain is called supply chain surplus. The competition between enterprises has been replaced by the performance of supply chains. The supply chain which creates more overall profit across the entire chain is the top performer. Sometimes the short term benefit to one entity has to be replaced by a long term decision impacting the surplus of the whole supply chain. Partnerships, joint ventures, franchise system, horizontal integration, vertical integration, mergers and acquisitions are all being performed in supply chains to make it better. The eagles' eye view is to see the whole interconnection of entities in the supply chain. The focal company or the engine driver is the one responsible to look after the performance of all carrier partners. It involves trust, commitment and collaboration for a number of years before these supply chains begin to perform effectively. Hence building a supply chain is a long term strategic program (Christopher 2016, Groover 2007, Chopra and Meindl 2007). The field of supply chain management becomes increasingly interesting and complex because, in most cases, the entities are part of more than one supply chain; hence it is perhaps needed to use the term 'Supply Web' (Chopra and Meindl 2007).

THE SUPPLY WEB

It is of utmost importance that the trade chambers and trade associations through careful formulation of data get a picture of the supply web of their industry. Once a clear picture about the interdependencies is established, then strategies can be explored for joint collaboration and efficient management. It is even more interesting to explore the global supply chain phenomenon. Enterprises in different countries are increasingly realizing that each individual country has potentials and advantages due to their resources, location, population, crops and minerals etc. Enterprises are increasingly relying on each other locally as well as at the global level. The global economy has evolved with complex and profitable supply chains being established (Christopher 2016, Groover 2007).

CHINA PAKISTAN ECONOMIC CORRIDOR (CPEC)

The China Pakistan Economic Corridor is the logistic gateway to regions which are still isolated from a large part of the earth. The labor potential, population, neighbors, resources, marine lanes and leadership of Pakistan, all indicate that infrastructure to build a supply web catering to the needs of millions of people is on the cards. The potential for connectivity from Russia and Central Asia could be developed as well as with the western regions of China. Gwadar is a deep sea port providing the connectivity to the sea lanes of the Indian Ocean.

CPEC is part of the BRI program which aims to connect China with other markets for trade and commerce. Chinese

TABLE 2. Industry 4.0 technological elements

Industry 4.0 technological elements		
Additive manufacturing	Robots	Internet of things
Augmented reality	Simulation	Cyber security
Big data	System integration	Cloud computing

TABLE 3. Elements of supply chain management

Supply chain management elements	
Supply chain strategy	Asset management
Supply chain planning	Procurement
Supply chain enterprises applications	Product life cycle management
	Logistics

TABLE 4. Elements of logistic supply chain management

Elements of logistic supply chain management	
Order processing	Inventory planning
Information system	Packaging
Warehousing	Transportation
Procurement	Customer Service

investment is shaping the infrastructure and logistic facilities of the partner countries. CPEC projects include energy, road, railway and social uplift projects. The CPEC projects' financial allocation has been presented in figure 1. A number of projects have been completed and others are in the process of completion (Abid and Ashfaq 2015, Hussain 2017, Butt et. al 2015). The major financial allocation is for the energy sector. The energy problems of Pakistan have been alleviated through CPEC. The eastern and western road corridors are being established from the Karakoram to Gawadar port. The main line ML-1 project of railways will also provide connectivity. The vision is to create an economic gateway to international markets and provide connectivity at a global scale. The Chinese Government bids to create trading patterns and logistics globally.

The energy sector is the major beneficiary in terms of number of projects and the investment made. The lag in the energy requirement of the country will be removed through CPEC projects. These energy projects obtained through diverse generation methods of solar, hydro, wind and coal, are speedily being completed. The mining sector especially coal mining is a priority with the aim to use locally produced coal in the relevant power plants. The rest of the projects are based on the supply chain logistic network of the country involving road, rail, mass transit and port development projects. These observations have been highlighted in the bar graphs in terms of number of projects as presented in Figure 2 and in terms of investment as shown in Figure 3.

METHODOLOGY

Multiple fields such as industry 4.0, supply chain management, logistic supply chain management and CPEC project have been synthesized. It was recognized that the CPEC project would bring huge and drastic changes in the way business will be done in the region. The fourth industrial revolution is beckoning; China is emerging as a world trade leader; Pakistan's strategic position geographically is being translated towards a practical logistic pathway through CPEC. The literature on these topics scientific as well as general has been analyzed and synthesized theoretically to envision a modern state of the supply web in the region. The development of CPEC projects is underway and an attempt has been made to model a future state created through CPEC facilities. A framework has been proposed which links the modern scientific concepts to the physical structure of CPEC. The project is continuously evolving and policy and decision makers are continuously striving to improve. Smart Factories are increasingly being enabled through industrial automation. The needs of the modern manufacturing industry have to be addressed in the CPEC project. A supply chain operational reference (SCOR) model has been developed which provides strategic insight into the advancement foreseen in supply chains, modern manufacturing, developing inputs and processes.

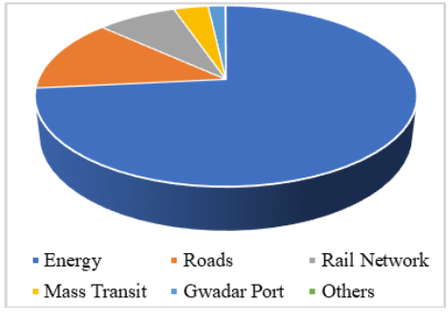

FIGURE 1. CPEC projects financial investment
Source: CPEC Quarterly Magazine, Spring Issue, Vol: 2, 2018

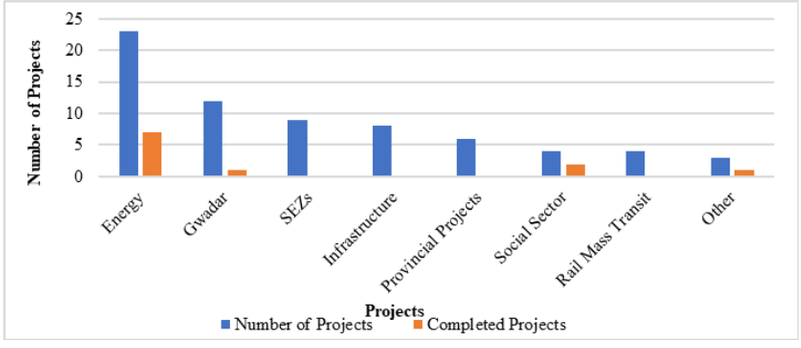

FIGURE 2. CPEC project details
Source: CPEC Quarterly Magazine, Spring Issue, Vol: 2, 2018

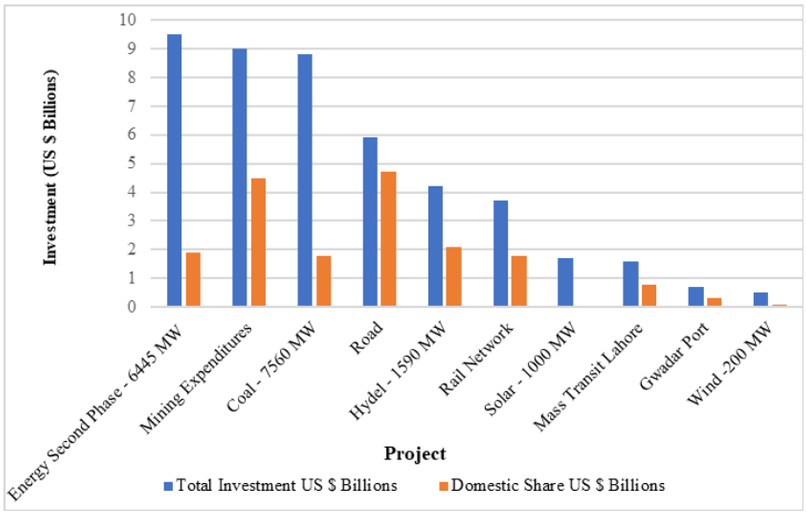

FIGURE 3. International and domestic investment in CPEC projects

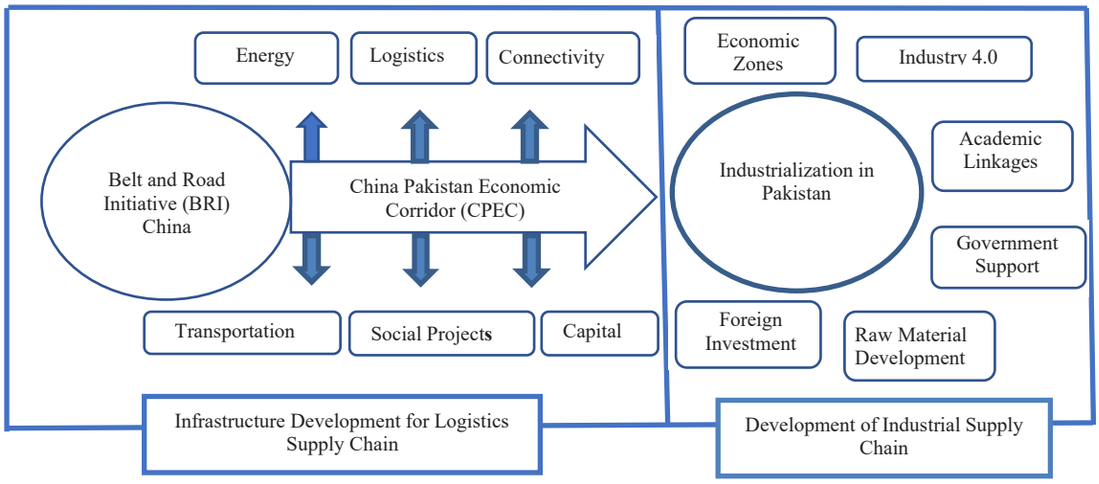

FIGURE 4. China-Pakistan economic corridor (CPEC) supply web framework

TABLE 5. CPEC supply web strategic SCOR model

Plan	Develop plan for CPEC supply web.
Source	Identify natural, hard and soft resources to develop across the region.
Make	Manufacture mass customized products through Industry 4.0.
Deliver	Through logistics developed by BRI and CPEC, form an industrial supply web.
Return	Reverse and forward movement of products, money and information across CPEC supply web.

RESULTS AND DISCUSSION

The future state envisioned is one which is built on infrastructure development of CPEC and BRI. The energy, rail, roads, port, airport, social projects and internet connectivity projects, all are being undertaken through CPEC in Pakistan. The industrialization of the country is the ultimate goal. The logistic infrastructure being developed will fuel the development of a supply web across multiple countries, enabling supplies from across borders and creating economic benefits for workers in the region. It is important to understand the elements of logistic supply chain management. Logistics will involve the movement of raw materials, work in progress and finished goods across regions of China, Central Asia and Pakistan. Finances will be exchanged through modern banking and payment systems. Manpower will have the option to utilize their skill at various nodes. There is a need to develop the manpower, raw material resources, academic linkages and supply chain of Pakistan to move towards the technologies of industry 4.0. The model presented in figure 4 highlights the aspects which are of importance for CPEC supply chain

and indicate the future state of affairs in context of modern manufacturing. Creation of smart factories, development of manpower trained in automation, computer programming and modern manufacturing, development of mining to exploit raw materials, connectivity and building communication through usage of internet technology, academic linkages in education and research development with universities of the region are aspects which are presented in the CPEC Supply Web Model.

A strategic point of view is elaborated in the SCOR Supply Chain Model in context of the BRI and CPEC Supply Web as presented in Table. 5. The SCOR Model is developed on the following steps, plan, source, make, deliver and return which are fundamental to any supply chain (Fasika Bete Georgise 2016, Gul Esin Delipinar 2016). This paper proposes effective plans for creating an integrated supply web. This is done through identification and sourcing of all natural, hard and soft resources available in the region. The making the products will be through industry 4.0. The development of the supply web logistic infrastructure and subsequently forming the industrial supply web to deliver logistics will be possible. The reverse and forward flow of products, money, material and information will be made possible across the whole supply web.

CONCLUSION

It is extremely important for policy makers and business community in Pakistan to recognize the importance of the installation of modern logistics infrastructure through the CPEC program under BRI China. The logistics will be much improved with lower lead time, secure passage, connectivity and flow of goods. The region will witness a boom in power generation, logistics connectivity, and development of industrial zones. It is foreseen that a global connection from Russia and Central Asia to the warm waters of the Indian Ocean could be developed. The western part of China will be opened for trade. The manufacturing, agricultural and tourism sectors of Pakistan are expected to get benefit through increased cooperation with China. Increased attention from foreign investors to cater to the needs of large population of the region as well as supplying goods to the other nations will be possible. Education, training and development of modern factories can aid manufacturing. The connectivity, both physical and virtual, is being established along with development of special industrial zones. The creation of modern factories and units especially from foreign investors will create new economic opportunities. Airports, railways and ports are being developed. The training of manpower and cooperation of academia are being enhanced. The ultimate goal of poverty alleviation and creation of wealth, employment, trading and opportunities for business should be at the forefront in all endeavors. The inputs and resources in association with modern manufacturing practices, if channelized through an effective integrated supply web, can create economic benefits for the whole region.

DECLARATION OF COMPETING INTEREST

None.

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