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Che as minister: the promotion of science and technology for Cuba's socialist development

Helen Yaffe 

Economic and Social History, University of Glasgow, Glasgow, UK

ABSTRACT

As Minister of Industries in Cuba between 1961 and 1965, Che Guevara addressed the challenge of increasing production and labour productivity in conditions of underdevelopment and in transition to socialism, without relying on capitalist mechanisms that undermine the formation of new consciousness and social relations integral to socialism. Under capitalism, Guevara noted, competition for private profit drives the application of science and technology to industrial development, revolutionising the productive forces. Socialist governments must find alternative methods. To these ends, Guevara set up nine research and development institutes, focussing on sugar cane derivatives, minerals and metals, the chemical industries, agricultural by-products, the mechanical industry, technological innovations, and automation. He established an institutional framework to begin experimentation at different ends of the production chain simultaneously. The short-term results were inevitably limited, but more significant than the productive achievements attained was the methodology introduced, the application of science and technology to production.

KEYWORDS

Che Guevara; Cuban Revolution; socialist political economy; science and technology

Speaking at the Cuban Academy of Sciences in mid-January 1960, one year after the Cuban revolutionaries took power, Fidel Castro declared: 'The future of Cuba will be a future of men of science' (Castro Ruz, 1960). This must have seemed like a pipe dream, given the backward state of Cuban scientific research and generally low level of literacy and education.¹ The Revolution, declared Castro, needed thinking people who would put their intelligence to 'good', on the side of 'justice', in the interests of the nation. A succession of programmes, regulations and institutions followed; the Literacy Campaign in 1961, the University Reform Law of 1962, the establishment of the National Centre for Scientific Research in 1965. New schools, colleges and universities were built, new teachers trained. Thousands of technicians, educators and advisors arrived from Latin America, the socialist countries and elsewhere. Thousands of Cuban students studied overseas.

The endeavour to harness science and technology for national development was championed by Ernesto 'Che' Guevara, Cuba's Minister of Industries, between 1961 and 1965. Guevara developed a unique system of economic management for the transition to socialism in Cuban conditions, known as the Budgetary Finance System (BFS). His practical policies were the product of three lines of enquiry: the study of Marx's analysis of the capitalist system; engagement in contemporary

CONTACT Helen Yaffe  helen.yaffe@glasgow.ac.uk

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socialist political economy debates; and recourse to the technological and administrative advances of capitalist corporations (Yaffe, 2009).

Guevara perceived socialism as a phenomenon of both technology and consciousness. Advanced technology, including electronics, automation and computing, would facilitate productivity gains based on technological innovations and administrative controls and not by appeals to workers' self-interest, via material incentives, or by increasing labour exploitation. Adopting the most advanced technologies and techniques would facilitate Cuba to 'burn through stages' of development. Guevara insisted:

We cannot follow the development process of the countries which initiated capitalist development ... to begin the slow process of developing a very powerful mechanical industry, before passing on to other superior forms, metallurgy, then chemicals and automation after that. We have to burn through stages. And ... try always to make use of the best world technology, without fear. (Guevara, 1962a, p. 140)

Under capitalism, noted Guevara, competition for profits drove the application of science and technology to industrial development, constantly revolutionising the productive forces. The socialist government had to find a method for fostering the application of science and technology to production without relying on capitalist mechanisms, which would hinder Cuba's socialist transition. An immediate rise in productivity could be achieved just by rationalising production, improving wealth distribution and offering incentives to workers. However, the precondition to sustained economic development was research and innovations. How could this be achieved in an underdeveloped country emerging from dictatorship and imperialist domination via violent revolution – blockaded, attacked and in transition to socialism?

In the search for solutions to this challenge Guevara set up an apparatus within the Ministry of Industries (MININD) to institutionalise research and development for industrial production.

How to industrialise Cuba?

Following the Revolution of 1959, the UN's Economic Commission for Latin America sent an advisory mission to Cuba to promote its import substitution industrialisation (ISI) strategy for bolstering national (capitalist) development.² Guided by this ISI approach, the Cuban trade mission to the socialist bloc which Guevara headed in October 1960, purchased factories according to a list of finished products needed in Cuba, with the intention of replacing imports. Within a year and a half Guevara complained this had been the wrong criteria:

We worked with our vision fixed on the substitution of imports of finished goods, without seeing clearly that we can't produce those articles without having the raw materials they need ... We continue to be largely dependent on foreign trade to resolve our problems. (Guevara, 1962a, p. 103)

He listed factories for brushes, screws, pickaxes and shovels, electric solders, barbed wire, among others, which Cuba had purchased because the finished product was needed, but which relied on imported materials to manufacture. This was a costly mistake; the US blockade was cutting off imports from the capitalist world.

In August 1961, the National Production Conference confirmed that the revolutionary state would maintain the sugar industry's historic role as Cuba's principal export, to secure vital imports, serving as the basis of accumulation for longer-term investments in industry and social welfare. Guevara concurred, but advocated an industrialisation strategy using endogenous resources, including sugar cane and its derivatives, and pursuing a diversified chain of production with

both horizontal and vertical integration: ‘... We have to develop cotton together with the textile factory; to develop iron together with the factories that will consume iron ... From sugar everything should be extracted ... sugar [could] serve as a primary material’ (Guevara, 1962b, p. 286). He pointed to the use of pork to produce lard in the United States as an example.

As the US government pressured other capitalist countries not to trade with Cuba, the revolutionary state was obliged to import equipment from the socialist bloc, which was sometimes two decades behind that existing in advanced sectors of Cuban industry in 1958. Edison Velázquez, director of the Consolidated Enterprise (*Empresa Consolidada*, or EC) of Nickel in MININD explained:

Many factories turned out to be inefficient, because we depended on what the Russians and the socialist camp had achieved, and they were behind. You could say these factories were obsolete. This wasn’t Che’s fault. The Yankees wouldn’t sell us factories ... we had to make more effort, it was more work for the country. (Velázquez, 2006)

Nonetheless, Guevara acknowledged the essential support received from the socialist countries, which provided credit, advisors, technicians, and other specialists (Guevara, 1962a, p. 100). All MININD’s vice ministers and directors were assisted by specialists from throughout the socialist bloc or Latin American communists and sympathisers. Guevara asserted that ‘all the socialist countries with the capacity to do so have contributed, and contribute day after day to our Revolution, with identical enthusiasm’ (Guevara, 1964, p. 139). By the end of 1964 there were 640 foreign technicians working in MININD, 492 of them from socialist countries (MININD, 1965, p. 78). Most trained Cubans to operate new plants and technologies or worked in research and development institutes. From 1964 to 1965, some 2000 Cubans received onsite training for plants under construction (Sáenz, 2005b, p. 206).

Meanwhile, thousands of Cubans went to the Soviet bloc. On 31 December 1964, MININD had 1271 Cubans abroad studying at universities, receiving technician training or other ‘worker qualifications’ (MININD, 1965, p. 78). This assistance, Guevara said, would create Cuban technicians who would construct Cuban factories built with machines designed by Cubans, using domestic raw materials, processed with Cuban technology (Guevara, 1964, p. 139). In the short term, however, he acknowledged the advantage enjoyed through socialist bloc assistance in mitigating US sanctions and consolidating the Revolution.

The Soviet Union did this alone; without friends, without credit, surrounded by ferocious adversaries, in the middle of a bitter struggle, even within its own territory. We do this in far superior conditions than those of the Peoples’ Republic of China, and those of the peoples’ republics of Europe, which came out of destructive war. (Guevara, 1962a, p. 118)

Guevara did not criticise the Soviets for the relative backwardness of their technology *per se* but for the disparity between the high level of research and development applied to military technology and low investment channelled to improving civilian production. In addition, he opposed ideological resistance to transferring the most advanced technology from the capitalist world. This ‘error’, he said ‘has cost them in terms of development and in terms of competition in the world market’ (Guevara, 1962b, p. 289). For example, Guevara criticised the Soviet’s rejection of cybernetics on ideological grounds, ‘cybernetics is a branch of science that exists and that should be used by man’ (Guevara, 1962c, pp. 318–319).

Technology has no ideology *per se*, he insisted: ‘a tractor has a function: to plough ... why are we going to take the technology of a socialist tractor in place of a capitalist one, if the capitalist one is

better?’ (Guevara, 1963a, p. 422). He cited Polish economist Oscar Lange’s prediction back in 1953 that new countries entering socialism would adapt the modern capitalist technology they inherited, speeding up the construction of socialism (Guevara, 1963a, p. 421). The origin of the BFS lay in the capitalist corporations of pre-Revolution Cuba, and it was, therefore, more progressive than the Soviet Auto-Financing System (AFS), which developed out of 1920s pre-monopoly Russian capitalism, he concluded.

Technological incompatibility was also a problem, as explained by Tirso Sáenz, named director of the nationalised petroleum industry in 1961.

Refineries are designed according to the type of oil they are going to process. Soviet petroleum was different from the Venezuelan oil that we received before – it had a higher content of salts and sulphur. The corrosion problems were terrible. The crude was eating away the pipes and equipment and we had the blockade so we couldn’t get spare parts from anywhere. (Sáenz, 2005)

Guevara advocated a long-term development strategy of fostering industrialisation based on endogenous resources with investments in science and technology to overcome trade dependency. While the National Institute of Agrarian Reform (INRA) were responsible for developing the food industry and other agricultural derivatives, Guevara announced in 1962 that MININD would: ‘orientate ourselves towards four lines of development: metallurgy, naval construction, electronics and *sucroquímica* [chemical derivatives from sugar]’ (Guevara, 1962a, p. 105).³ The prerequisites were the rational exploitation of natural resources, creation of a mechanics base and training at all levels.

To address the lack of adequate training and infrastructure in the existing academic institutions, Guevara set up nine research and development institutions within MININD, focussing on sugar cane derivatives, minerals and metals, the chemical industry, agricultural by-products, the mechanical industry and technological innovation and automation. This institutional framework would initiate experimentation at both ends of the production chain, raw materials and manufacturing simultaneously. Not all these projects could possibly come to fruition in the short term, however, more significant than the productive achievements was the methodology introduced, the application of science and technology to production. The following discussion about nine research and development institutes set up within MININD is informed by archive documents and interviews with those involved.

In 1964, these research institutes accounted for 53.2% of MININD’s total costs, reflecting their prioritisation. They were located outside the ministry building but integrated under the organisational and financial structure of the BFS, receiving a planned budget for investments and salaries, and operating with some independence.

For the purpose of analysis, the research apparatus has been divided into three categories: first, those concerned with the sugar industry; second, those involving the extraction and exploitation of natural resources (excluding sugar); and third, naval construction, electronics, and automation.

The sugar industry

The pre-revolutionary Cuban economy was dominated by the sugar industry; 75% of arable land was controlled by sugar companies, half of which they left fallow. They employed 25% of the Cuban labour force, but only 25,000 workers full time, with up to half a million workers hired for the labour-intensive harvest lasting two to four months, and afterwards dismissed for the *tiempo muerto* (dead season). Underemployment was integral to the sugar industry and plantation workers

constituted a rural proletariat with a history of class-conscious militancy. Cuba was the world's largest exporter of sugar in the 1950s; sugar and its by-products accounted for 86% of exports.

The sugar industry was dominated by US interests. In 1955 US investors controlled 40% of raw sugar production (US Department of Commerce, 1956, p. 37). The United States received 80% of Cuban sugar exports while US imports flooded Cuba's internal market. The US imposed a quota for sugar imports, which disincentivised investment, contributing to the industry's stagnation and serving as an instrument of political-economic control over the Cuban government. No new sugar mills had been founded since 1926 and by 1951 the World Bank warned: 'Cuba's standard of living ... depends mainly on an industry which stopped growing many years ago' (IBRD, 1951, p. 5).

For most Cubans, the sugar industry was associated with slavery, racism, poverty, unemployment, underdevelopment and imperialism.⁴ The first instinct of many in the revolutionary government was to replace sugar with diversified agricultural production, manufacturing and heavy industry (Boorstein, 1968, p. 205). However, as Cuba shifted to trade with the socialist countries, the government fell back on a development strategy where sugar exports were the mainstay of capital accumulation. In 1963, Guevara acknowledged:

The entire economic history of Cuba has demonstrated that no other agricultural activity would give such returns as those yielded by the cultivation of the sugar cane. At the outset of the Revolution many of us were not aware of this basic economic fact, because a fetishistic idea connected sugar with our dependence on imperialism and with the misery in the rural areas, without analysing the real causes: the relation to the unequal balance of trade. (Cited by Pollit, 2004, p. 323, fn 6)

Given favourable trade deals with the socialist bloc, the revolutionary government believed it had redressed the unequal balance of trade.⁵ While sugar production remained pivotal to Cuban economic development, Guevara sought to mechanise its cultivation and develop a secondary manufacturing industry on the back of it.

There were three incentives to mechanise the sugar cane harvest. First, the shortage of *macheteros* (cane cutters) following the post-1959 rural-urban migration as real wages rose and employment was created. The harvest in 1961 required 200,000 volunteers to be mobilised. The long-term solution was mechanisation. Second, to humanise the work so that in the near future, Guevara said, 'those who speak of cutting by hand, loading by hand, would be considered to be proposing inhumane, bestial work, something from the past' (Sáenz et al., 2003, p. 151). Third, to cut the costs of production and raise productivity (Guevara, 1962a, p. 108). This would be achieved by mechanisation and development of sugar derivatives; value-added products using sugar as a raw material.

Alfredo Menéndez, director of the EC of Sugar in MININD, recalled how Guevara's experience of voluntary labour in the cane field strengthened his resolve to mechanise the harvest:

It was a hot day ... already 11am and everyone was tired, but they had not finished cutting parts of the cañaveral [cane field], which means that the cane can't be picked up. Che sat down to rest in the shade. When people saw this, they stopped working too. I explained to him why you had to finish the cañaveral. He said: 'Damn, I am going to get up and cut cane; but this is slave's work, this has to be mechanised!'. (Menéndez, 2005a)

Attempts pre-1959 to mechanise the sugar harvest had been resisted by *macheteros* who relied on this back-breaking work to survive (Cushion, 2016; US Department of Commerce, 1956, p. 34).⁶ The minor feats accomplished by Guevara's mechanisation project were perhaps more significant in assuaging resistance to mechanisation than in productive results. Confident that the Revolution would provide alternative employment and social welfare, militant sugar workers dropped their resistance to mechanisation. 'In the epoch of the Revolution, these machines did not mean

unemployment' explained Miguel Ángel Duque de Estrada Ramos (2005), who was head of the Office of Special Issues which set up the mechanisation task force. Young *macheteros* moving to cities to study and work had no wish to return to manual labour in the countryside. They stopped opposing mechanisation and *machateros* contributed to these efforts.

1961 Commission for the Mechanisation of the Sugar Harvest

Have you seen film footage of Che cutting cane? That was one of the first prototypes. He was struggling to breathe ... The dust from the sugar cane was terrible for him. Che was one month, 30 days cutting cane, with a terrible asthma attack! (Sáenz, 2005)

The Commission for the Mechanisation of the Sugar Harvest was set up in early 1961 and headed by Duque de Estrada and Menéndez. The first problem was the lack of materials; the US blockade was already hurting. Duque de Estrada Ramos (2005) explained: 'Che knew the task of mechanisation would take a long time, but he believed that you had to make a start quickly'. It took nine months to create an enterprise to construct the machines, but with cooperation between the mechanics and the sugar mills and assistance of engineers from the Soviet Union, Czechoslovakia, Hungary, Argentina and Bulgaria, by the start of the 1962 harvest the Commission had built more than 500 cane cutters and 500 *alzadoras* (retrievers). The *alzadoras* were a simpler design than the cutters and more successful in raising productivity from the outset. They retrieved piles of cut cane to load onto the mill transportation. Up to 40% of the *macheteros* labour had been consumed by loading cane (Menéndez, 2005b).

Circumventing the US blockade, Guevara had one US and one Australian cane cutter imported to serve as prototypes. The engineers adapted the design to build on top of tractors imported from socialist countries (Borrego Díaz, 2001, p. 235). 'Adapting the cutters to Cuban conditions was a long process' explained Duque de Estrada Ramos (2005). However, the Commission did not delay in introducing the first prototypes. The first version of the cutters was simple and problematic. Speaking to sugar workers after six hours of cutting cane on the machine that morning and ten hours the previous day, Guevara described them as in the experimental stage, liable to breakdowns, especially with inexperienced operators. 'The cutter, as it is today, is cutting cleaner than the average *machetero*', he announced, while inviting constructive criticisms to improve the machine. 'The machine is dangerous' he warned, admitting that the previous Monday the blades had broken, injuring a *compañero* who had not taken precautions (Guevara, 1963b, p. 31). Guevara challenged Orlando Borrego, his deputy in MININD, to a competition on those first cutters. They worked from 6am to 6pm, with a 15-minute break. 'When we finished the work, almost at dusk', Borrego Díaz recalled (2001, p. 236) 'Che appeared jubilant, and with his short breaths [from asthma] he spoke about the advantages and disadvantages of the cutter and ended by saying that the battle to mechanise cane was being won'.

'Che drove me crazy', said Menéndez (2005b), about Guevara's insistence on inaugurating equipment for transporting *azúcar a granel* [sugar in bulk], built but abandoned due to workers' resistance before 1959. The Cuban engineer Roger López who had designed the equipment was preparing to join his family in the United States, a move complicated by migration controls at both ends. In 1962, Guevara instructed Menéndez to contact López to request assistance. Having agreed to the project, 'because he wanted to see his work finished', López was provided with a car and a 'revolutionary engineer' to shadow him (Menéndez, 2005b). The *azúcar a granel* equipment was inaugurated, alleviating the back breaking work of loading 300 lb sacks onto boats in the ports. Guevara then facilitated López's exit to join his family.

It was a similar story to the *centros de acopio*. Mechanising cutting and retrieving necessitated mechanical cleaning of the cane before processing. Duque de Estrada Ramos recalled (2005) that before 1959: ‘an engineer in Camagüey had designed a plant to “dry clean” the cane with air to remove the earth and straw’. His design was abandoned after workers’ opposition. Another Cuban engineer Robert Henderson Kernel assisted the Mechanisation Commission to complete the construction of the *centro de acopio*. Henderson inaugurated five *centros de acopio* and worked on a combine harvester, mounted on a bulldozer, which cut a whole furrow of cane in one go (Duque de Estrada Ramos, 2005). For Guevara the Commission’s importance was not just measured in concrete results, but in the Revolution’s audacity in working towards complex goals. He told sugar workers: ‘objectively the cane cutting machines represent a triumph for the Revolution, showing its capacity to focus its forces in order to resolve problems’ (Guevara, 1962d, p. 127).

The mechanisation project continued after Guevara’s departure from Cuba. However, only 1% of the harvest was mechanically cut by 1970 (Pollit, 2004, p. 324). However, with Soviet assistance from that date, and with the increasing use of Cuban components in new combines, by 1990, that figure had reached 71% (Pollit, 2004, p. 327). In 2004, Fidel Castro announced: ‘today, there is no one left that cuts sugar cane by hand’ (Castro Ruz, 2004). Guevara’s ambitious project was achieved in Cuba’s most important productive sector.

1963 Cuban Institute of Research into Sugar Cane Derivatives (ICIDCA)

... the day will arrive when the derivatives of sugar cane have as much importance for the national economy as sugar has today. (Guevara, n.d., ICIDCA)

The ICIDCA was established to investigate the potential for establishing new manufacturing industries based on sugar as a raw material, achieved through vertical integration of primary and secondary sectors, and increasing the value of sugar-based exports. The principal sugar by-products were syrup (molasses) from cane juice, already used to make alcohol, principally rum, and bagasse, the cane after the juice has been extracted. Bagasse had long been used as fire fuel in sugar mills, but Guevara aspired to use it to manufacture cardboard and paper and synthetic fibres, including rayon and furfural which has multiple uses in the medical industry, cosmetics and animal feed. This would create industrial zones around the mills, bringing employment and development to rural areas. Internationally, little research had been undertaken on sugar by-products. The technology required hardly existed, so it could not be imported. Success would largely depend on the ICIDCA’s ability to develop its own technology. Given the lack of scientists and technicians and the absence of a mechanical industry in Cuba, advances would clearly be made very slowly and require significant investment. However, Sáenz also acknowledges that Guevara’s vision was underappreciated within Cuba: ‘Che said “let’s manufacture products with more value added than sugar, so that sugar is a sub-product and plastics, pharmaceutical drugs and so on are the main products”. But I think we missed the point at that time’ (Sáenz, 2005).

The short-term goals were less ambitious. A 1964 report said: ‘the future of the ICIDCA is in the growing emphasis on the processes of fermentation ... to have advanced technology in this area’ (ICIDCA, 1964, p. 101). With the assistance of East German specialists, they developed research centre technology, including a pilot plant set up in a former US sugar mill, for extracting dextran (used medically as an antithrombotic and to reduce blood viscosity) from sugar cane. They also developed technology for producing torula yeasts for cattle feed. Sáenz (2005b, p. 171) confirmed that: ‘Che was very satisfied with the results obtained’.

In June 1964, the EC of Sugar split from MININD to become the Ministry of Sugar (MINAZ) headed by Borrego. The ICIDCA passed over to MINAZ's jurisdiction where it remains today. Luis Gálvez, who Guevara once called 'the administrator of the future', was its director for over 30 years (Gálvez, 2006; Sáenz, 2005b, p. 55).

The extraction and exploitation of natural resources

Cuba has among the world's largest known reserves of nickel. In 1959, there were two nickel mines, both in Oriente province. The Nícaro mine was owned by the US government and the Moa mine by a private US company, the Freeport Sulphur Company. The nickel was sent to the US for processing. A 1961 report to the US President highlighted the importance of Cuban nickel for the development of the US military industry, including space exploration projects (Borrego Díaz, 2001, pp. 140–141).

Nícaro was founded in 1943 during the Second World War and expanded for military purposes in 1952 during the Korean War. By 1958 the plant was valued at \$87 million and its annual production represented 11% of world supply, excluding the socialist countries (*Time Magazine*, 1958). The plant had its own electricity supply and employed 4000 workers in continuous production. A manganese plant in Felton, a town outside of Nícaro, had another 400 workers. Production stopped at Nícaro in 1960, after the US government refused to pay a new 25% tax imposed by the revolutionary government on exports. The plant at Moa was inaugurated in 1958 with more complex, modern technology, employing 1600 workers in continuous production, and valued at \$75 million. It was abandoned the following year after the Revolution. US technicians left the island and US imports vital for production, particularly ammonia, were cut off.

'The technological dependence of the nickel industry on the US was total', stated Borrego Díaz (2001, p. 141). Restarting production at Moa and Nícaro were major achievements; paralysis would have been politically, as well as economically disastrous, leaving 6000 Cubans, including skilled workers, unemployed. The Revolution relied on the support of the mine workers to re-establish production, and on the expertise of Soviet specialists sent to assist. One Cuban engineer, Demetrio Presilla played an essential role at Nícaro. Presilla rejected tempting offers to work in the US because of racism in that country (Gálvez, 2006; Regueira Ortega, 2006). Initially he also refused to co-operate with the Soviet technicians, on the basis of anti-communism. According to Benigno Regueira Ortega, head of the Cuban Mining Institute (ICM) from 1960 following the nationalisation of the mines, Presilla finally he agreed to collaborate: 'because of his respect for Che' (Regueira Ortega, 2006).

From February 1961, responsibility for mining was transferred to the new EC of Nickel set up in MININD. Guevara also established the Cuban Institute of Mineral Resources (ICRM) to conduct research in cooperation with the EC, thereby establishing a model for collaboration between research institutions and production enterprises that is an established feature in Cuba. New mines were opened with co-ordinates provided by the ICRM. A new railroad and other facilities were built with equipment imported from the USSR and England.

From 1963, the administrator at Nícaro was Luis Gálvez, a young chemical engineering student. 'My main role was to get a good understanding of that complex technology, to establish good relations with the workers and take a lead on the technical side' he explained. 'I had the factory and the mine 20 kilometres away. I practically lived in the factory' (Gálvez, 2006). The ammonia necessary for nickel extraction arrived in weekly shipments from the USSR, which also provided credit for Cuba to purchase spare parts from the west. The credit was repaid in nickel.

Restarting production at Moa was an even greater accomplishment. The Soviet engineers sent to assist were unfamiliar with the modern technology, so Guevara tracked down and met with technicians and engineers working at the plant before the Revolution. They were now mostly reemployed in Havana and most planned to leave the country. Emphasising the vital role of the mine in Cuban development and the importance of their own contribution, he persuaded them to return to help restart the Mao mine, offering to facilitate their departure from Cuba subsequently. An Indian engineer Dr T K Roy was also tracked down abroad and agreed to travel secretly to Cuba to help rehabilitate production. Borrego described this as a defeat for the ‘yankee government’ which showed that ‘revolutionary daring could triumph with decisive and intelligent work when faced by a powerful adversary’ (Borrego Díaz, 2005, p. 144).

New mines were opened which had various metals with productive potential and economic value. Gálvez (2006) explained that Guevara and Castro envisaged moving beyond the production of nickel, which is an intermediary product, to produce stainless steels for use in the chemical and food industries. This was achieved in the 1980s, but in Guevara’s time the principal achievement was to restart nickel production and shift exports to the USSR.

1961 Cuban Institute of Mineral Resources [ICRM]

We must search for mineral resources ... it is a task for everyone. We must prepare many geologists or mine engineers ... and do the industrial preparation to get at those metals ... (Guevara, 1961, p. 276)

Oil was first extracted in Cuba in 1881, but with little economic significance (Morales). Only in 1954 did industrial production begin, at a well in central Cuba. The consequent exploration by foreign oil companies between 1954 and 1957 revealed small reserves in four locations. Following the Revolution, a new law enabled the government to collect technical information from the oil companies granted a concession under Batista’s regime. In protest, companies withdraw from the island. Consequently, the government set up the Cuban Petroleum Institute (ICP) to lead the industry. With assistance from Argentinian specialists the first new well was opened up in May 1960.

In 1961, the ICRM was established to study the mineral and petroleum mines under production and begin locating and prospecting for mineral resources. It was MININD’s first research centre. There were only two geologists in Cuba, so the institute relied mainly on Argentinian, Soviet and Czechoslovakian geologists. From 1963, it was directed by Jesús Suárez Gayol, a captain in Guevara’s Rebel Army column. In 1963 the ICRM’s annual report concluded: ‘the real possibility has emerged of finding [petroleum] in some zones. We must continue the investigations to see if it is possible to reduce imports which consume \$80 million every year’ (ICRM, 1963, p. 80). The institute was instructed to produce a geological map of Cuba: ‘with special practical consideration for the economic problems of the country, such as an increase of reserves and the prospecting of supplies of those minerals which substitute imports and would be a source of hard currency’ (ICRM, 1962, p. 591).

In 1964, 21 oil wells had been finished and 34,343 tonnes of oil extracted, up from 27,800 in 1959, but below the peak of 79,200 in 1956 (MININD, 1964, p. 84; Morales, n.d.). The Institute had calculated Cuban reserves of over a dozen metals (including iron, magnesium, copper and gold) and located the necessary primary materials for making cement (MININD, 1964, pp. 84–87).

Suárez Gayol organised ‘peoples’ explorations’ to search for minerals.⁷ In 1964 a book entitled *Geology in Cuba* was published to educate and train new Cuban geologists. Guevara wrote the prologue outlining the objectives, weaknesses and challenges the ICRM faced, while praising: ‘our

capacity to learn from our contact with the most progressive scientists of the most advanced fraternal countries, as much in technology as in organisation' (Guevara, 1964a, p. 741). By 1964, 153 foreign specialists worked in the ICRM.

In 1965 the ICRM was searching for rare mineral and copper reserves to serve as the foundation for a future electronics industry and investigating the organisational and technical-material requirements for drilling the sea around the Keys in the north coast of central Cuba where Guevara correctly believed there were oil reserves (Gravalosa, 2006).

1962 Cuban Institute of Mining and Metallurgy Research (ICIMM)

We have lots of iron ... nickel, cobalt, chrome, *manganese*; there is a set of minerals that permit us to make alloys, to make special metals when we have developed our steel and iron industry, and furthermore, we have copper which is also a really important metal. That means that we have to ... develop with audacity, to go on creating our own technology ... here there are no metallurgists, but there can and should be. (Guevara, 1961, pp. 286–287)

Cuba is abundant in *lateritas*, reddish ground in humid tropical regions, rich in minerals, iron, nickel, cobalt and albuminate. In 1962, Guevara set up the ICIMM, to complement the work of the ICRM, in 'developing and applying new technologies' in the mineral and metallurgy branches, focussing on *lateritas* whilst searching for other natural resources (magnesium and dolomite) and increasing the extraction of copper for future utilisation in the electronics industry (MININD, 1962, p. 592). In addition, the ICIMM was to develop technology and investments to expand a steel plant in Havana, assist a metal plant in Pinar del Río and instruct MININD enterprises on the development of the iron and steel industry in the west (Sáenz, 2005b, pp. 160–161).

The ICIMM's achievements were limited. While Sáenz (2005b, p. 163) largely blamed the managerial deficiencies of the Institute's director Faustino Prado, who soon left Cuba, he recognised that, 'it was impossible to achieve technological results of magnitude within only two or three years of work'. Gálvez (2006) explained that while good results were achieved in separating cobalt from nickel in pilot plants, industrial application required huge investments, which were just not available. The USSR was interested in importing Cuba's nickel, but not in manufacturing cobalt, so they lacked an incentive to invest.

1962 Cuban Institute for Technological Research (ICIT)

The main task of the ICIT is in agriculture, to facilitate our industrial development and for the maintenance of botanical science ... with scientific controls from the planting of the seed up to industrial exploitation. (MININD, 1964, p. 143)

The ICIT was founded in 1962 to facilitate the industrial application of agricultural products and other plants, with a view to import substitution and the creation of new products with strong markets (MININD, 1962, p. 590). Guevara endeavoured to strengthen the links between agriculture and industry, introducing industrial management methods to agriculture in a way which, Sáenz (2005b, p. 176) claimed, 'anticipated the idea of the future complex agroindustry'.

Taking over an abandoned mansion outside Havana, the ICIT constructed laboratories, pilot plants and workshops. By 1964, they were researching the textile branch and had invented a machine to wash fibre produced from the kenaf plant (MININD, 1965, p. 81). They conducted research on over a dozen plants and crops. The industrial potential of this flora ranged from fabric dyes, to sewing thread, fishing ropes, food colouring, animal feed, vegetable oils, perfumes, and so

on. Successful laboratory research was carried out for extracting tannin from Eucalyptus trees and other plants, and with inorganic pigments, using Cuban chromite as a primary material. The 1964 annual report recorded that the ICIT had conducted work related to the ceramics industry, ‘an interesting project linked to the manufacture of chemical earthenware’ (MININD, 1965, p. 81). It was also responsible for ‘studying the application of experimental cultivation being carried out in our experimental unit’ (MININD, 1963, p. 611), *Ciro Redondo*, discussed below.

1962 *Ciro Redondo* experimental farm

Che’s visits to the farm ‘*Ciro Redondo*’ were very frequent ... he instigated experiments with the new salary system based on conceptions which were part of the Budgetary Finance System ... *Ciro Redondo* developed a group of medicinal plants for the production of medicines, convinced of the future importance of ‘green’ medicine. (Borrego Díaz, 2001, p. 138)

An abandoned farm in Matanzas was taken over for MININD to carry out socio-productive and botanical or agricultural experimentation. It was named *Ciro Redondo* to honour a Rebel Army captain who died during the revolutionary war. The scientific-technical work was led by Guillermo Cid Rodríguez, a Cuban botanist who had pioneered the exploitation of kenaf, the study of forage and the development of horticulture for exports. Guevara described him as: ‘a scientist with calloused hands’ in praise of his intelligence and hard work (Hernández Serrano, 2007). In January 1962, 165 students from the Rebel Army school were sent to the farm; most had fought alongside Guevara and had low educational levels. Their challenge was to get 200 hectares of farmland productive within one year with little mechanical equipment and to combine agricultural work with evening study (Sáenz, 2005b, p. 178). A mathematical physicist, Dr Raúl Arteche Duque, directed the school at the farm.

Ramiro Lastre, a former Rebel Army soldier at *Ciro Redondo*, recalled 23 varieties of medicinal plants being cultivated and used in experiments. ‘At one stage we had Chinese scientists, a doctor of science and three agronomy engineers, who lived with us’, he recalled (Hernández Serrano, 2004). The main experimentation was with textile fibres, oleaginous plants, and tung trees and safflower for making paints. Cid headed two missions to Brazil to visit agro-industrial experimental centres and establish a programme for cooperation, but the project was frustrated by the military coup in Brazil 1964. Medicinal plants from *Ciro Redondo* were taken to the Hospital of Oncology in Havana where Cid’s wife, Cora Lazo Jesús, who held a doctorate in pharmaceuticals, and three other scientists, carried out laboratory experiments. She recalled: ‘we began to work with varieties of these plants. I worked as a chemist. The fourth floor of the building was practically part of the Ministry of Industries’ (Hernández Serrano, 2004).

In addition, *Ciro Redondo* was a site for social experiments in the organisation of work, management techniques, incentives structures and salary scales, aspects of the BFS (Yaffe, 2009, pp. 188–190). In 1965 *Ciro Redondo* was transferred to the new National Centre for Scientific Research.

1963 Cuban Institute for Development of Chemical Industry [ICDIQ]

The ICDIQ was created to develop the chemical industry ... For now, this institute should just work to create technology and build factories to match that technology ... to act as the investor organisation in relation to new plants. (ICDIQ, 1964, p. 98)

The ICDIQ was established in 1963 to address the lack of material and intellectual resources in this sector and collaborate with MININD’s Light and Heavy Chemical production branches, which

incorporated 12 ECs, including the EC of Pharmaceuticals. The institute built its own prototypes, pilot plants, and equipment. It was instructed: ‘to consider the satellite plants necessary for the supply of primary materials’ and develop technology for the extraction of steroids and carotene from the wax of *cachaza*, the outer film of sugar cane (MININD, 1962, p. 612). Later the ICDIQ was instructed: ‘to develop the industrial application of antibiotics, not only for human use, but also for animals’ (MININD, 1965, p. 116).

Its director Álvaro García Piñera was a chemical engineer lacking ideological affiliation to the Revolution. ‘He dared to do things irrationally’ complained Sáenz (2006), ‘he broke the laws of engineering. With a pencil and slide rule, he designed an antibiotics plant. That’s crazy!’. The plant failed to produce a single antibiotic and the factory was returned to yeast production. This scenario was repeated with ‘all the chemical plants García Piñera had announced and included in the ministry plans’ (Sáenz, 2005b, p. 175). However, even with a superior director at the ICDIQ, Sáenz concluded, much better results were unlikely. The Cubans were starting from scratch, with few scientists, little equipment and scarce capital. Vice Minister of Industrial Construction Ángel Gómez Trueba (2001, pp. 43–45), reflected that: ‘the lack of understanding and internalisation at that time about this sector had an adverse effect on socialist economic development’. Nonetheless a valuable idea and a research methodology were established, Sáenz said (2006): ‘The idea was excellent, to make an institute with what they call a complete cycle of innovation. The institute develops products at a scale where it can build pilot plants which, if successful, are turned into production plants’ (Sáenz, 2006). This innovation cycle methodology is applied today in Cuba’s research and development institutes.

1963 Cuban Institute for Machinery Development [ICDM]

They tried to organise the production of spare parts – to generate ideas, to train people, with the aim of producing our own spare parts. Cuba didn’t have a mechanical industry, only small workshops. They also tried to develop some machines ... This institute was the cornerstone for future developments. (Sáenz, 2006)

Guevara lamented that the Revolution’s early trade deals had excluded the purchase of a spare parts factory (Guevara, 1962a, p. 289). In 1963, he set up the ICDM to address the lack of capital goods and spare parts resulting from the US blockade and the shift in trade. Assisted by Soviet advisors, the ICDM worked to install spare parts factories and optimise the use of machines and tools already available in MININD (MININD, 1965, p. 116). Within one year, there was a 132% increase in the production of spare parts, a new mechanics plant was to be inaugurated in Santa Clara in 1965 and a metallurgy plant was under construction (MININD, 1965, p. 81).

The ICDM constructed agricultural machinery for sugar cane and kenaf. For example, in 1963, a kenaf cutter was built, and improved the following year. Another machine for stripping the bark from the kenaf plant was also improved in 1964 reducing the number of operators required by over 40%. A combine harvester was built for the sugar industry in 1964 and improved the following year. While the ICDM’s work was considered satisfactory, its principal weakness was the dependence on foreign technicians (MININD, 1965, pp. 82–83).

Naval construction, automation and electronics

MININD’s research and development institutes related to two of the four lines of development proposed by Guevara in 1962, metallurgy and sugar cane derivatives. Efforts to foster progress in the

remaining two sectors, electronics and naval construction, were integrated into MININD's main apparatus, rather than as research and development institutes, via the EC of Naval Construction, the Office for Automation and Electronics, the EC of Electrical Equipment and the EC of Electricity.

Naval construction

The naval industry offers prospects of enormous importance to Cuba, but it is not just one industrial branch. Rather it is made up of a complex of factories: metallurgy, motors of various types, cables, electrical equipment and electronics, carpentry, etcetera. (Guevara, 1962a, pp. 106–107)

As early as January 1959, Guevara spoke about the need for a merchant fleet as a corollary to Cuba's export industry (Guevara, 1959a, p. 19). Naval construction, he said, could be developed at a faster or slower pace, but it must be considered as an important aspect of Cuban industry, given the country's dependence on international trade (Guevara, 1959b, p. 300). Building domestic merchant ships would save Cuba millions of pesos on transport costs every year, given that 80% of trade had shifted from the US (150 kilometres away) to the USSR (8000 kilometres distance) and to the rest of the socialist bloc: 'Cuba will need to transport more than eight million tonnes [of sugar] in 1965 ... at least 80 ships will be needed just for Cuba'. Pre-empting objections to the huge investments required for a naval industry, Guevara (1962a, pp. 106–107) asserted that: 'in terms of hard currency, a ship would recoup a value of 2.5 million peso in five trips to Europe ... a succulent saving for a country such as ours, maritime exporter par excellence'. He pointed to other benefits: 'such as ships for the coastal trade, which is the cheapest form of internal transport, and the construction of an adequate fishing fleet'. With an expanded fishing fleet Cuba could substitute costly food imports with local fish and sea foods, to the benefit of the underdeveloped coastal regions.

In 1962, the EC of Naval Construction was set up in the Metallurgy Branch of the Vice Ministry of Basic Industry. It achieved few concrete results, however, and Guevara assessed its management negatively in 1964 (Guevara, 1964b, pp. 109–110). That year it fell 61% short of planned production, accounting for 25% of the total shortfall of that Vice Ministry (MININD, 1965, p. 10). Plans to expand the shipyards in Havana with Cuban architects and civil engineers were put aside because investment was not available (Gómez Trueba, 2001, p. 35).

After visiting shipyards in Poland, Sáenz advised Guevara that Cuba lacked the technological and economic capacity to build major transport ships. He was right. In Guevara's time, the EC of Naval Construction produced wooden fishing boats for Cuba's Gulf Fleet, which contributed to the increase in total fish production from 30,000 to 40,000 tonnes from 1960 to 1965 (FAO, 1967). Later developments in naval construction included iron and cement boats. Meanwhile, Cubans were trained in naval engineering in the socialist bloc, learning to operate and maintain the merchant ships acquired by Cuba from elsewhere over the years (Guevara, 2003, p. 13).

1962 Office of Automation and Electronics

Automation and electronics were a passion for Che as minister of industries. (Gómez Trueba, 2001, p. 44)

In January 1962 Guevara told MININD directors:

We are entering the era of automation and electronics. We have to think of electronics as a function of socialism and the transition to communism ... Electronics has become a fundamental political problem of the country. Today and tomorrow cadre must be prepared so they are ready in the future to take up the next great technological tasks and for the automation of an ever-increasing part of total production, the liberation of man by means of the machine. (Guevara, 1962e, p. 149)

Technological progress imposes the centralisation of the productive forces, he told MININD administrators, pointing to US power generators which, with a handful of operators, produced one million kilowatts each, greater than the total installed capacity in Cuba (Guevara, 1962f, p. 91). This should be a phenomenon of socialism and communism, he said:

In all the great modern, centralised and automated industries, man's activity should take place outside of production. In the future man will express his wishes through political institutions which are being created, and which will determine the types of production which the country needs. (Guevara, 1962f, p. 92)

Automation would permit political control over the economy. It could 'even accelerate transition to the new society ... Without automation, that is, without substantially raising productivity, we will take much longer to reach that stage' (Guevara, 1962g, p. 207). However, Guevara also cautioned that these steps could not be achieved quickly, describing automation as both an 'aspiration' and a 'precondition' for the development of a new society. 'But for this there has to be preparation' (Guevara, 1962g, p. 221).

In 1962 the Office of Automation and Electronics was established within MININD to find immediate solutions to concrete production problems whilst laying the foundations for future advances. The Office directed projects underway in the EC of Electrical Equipment, studying, repairing, and carrying out maintenance on the means of industrial control. It studied the feasibility of installing an electronic components factory and introducing automation in the sugar industry. It oversaw the training of electrical engineers and other technical cadre to operate imported equipment, build experience in the fields of electronics, cybernetics, instrumentation and computing, and to assess the possibilities for automation in industrial sectors (MININD, 1962, pp. 589–590, 1963, p. 610; Sáenz, 2005b, pp. 163–164).

Ultimately, there were few tangible results during Guevara's time. Ambitious projects were underway by 1964, including for the automation of the Maritime Terminal in Matanzas for sugar exports, and installation of a system to control *tachos* and evaporators (MININD, 1965, p. 80). However, the annual report complained that the Office suffered from: 'a lack of definition of objectives, a lack of technical cadre and internal organisational deficiencies'. Trueba recalled negotiations with Poland for the construction of a plant to assemble televisions in Cuba which: 'gave few results' (Gómez Trueba, 2001, p. 44). The tasks set were changed often and substantially.

The Office directed the School of Automation, where Czechoslovakian engineers taught Cuban technicians about automated control systems (Sáenz, 2006). Effectively, it was a theoretical school, lacking the technology for the applied aspect. In December 1964, 69 students graduated as mechanics of measurement and control. A further 39 students were studying instrumentation techniques and 28 were students of automation (MININD, 1965, p. 75). In 1964 the Office was instructed to lead on Guevara's plan to import computer components and assemble the machines in Cuba, reducing the cost of technology transfers and training up electrical engineers until they were capable of manufacturing computers domestically.

According to Oscar Fernández Mel, a doctor in the Rebel Army, Guevara was already thinking along these lines in early 1959: ‘Che was interested in computing, the automation of management, of the economy and the factories’, he affirmed. Clearly there were some successes, as Mel recalled: ‘one of Che’s happiest moments was when the EC of Perfumes had managed to automate their supply. He created the first school of computing and acquired the first computers ... Che was the pioneer of the introduction of computing in Cuba’ (Fernández Mel, 2006).

Conclusion

We are inaugurating an epoch in which scientific knowledge is, and will increasingly be, the main force that determines our rhythm of development and our capacity to ‘burn through stages’ in the construction of socialism. (Guevara, 1962f, p. 148)

Guevara’s promotion of science and technology within MININD was part of his theoretical understanding that communism should arise out of the highest stage of development of the productive forces. The greater the level of automation and centralisation, the greater would be the potential for conscious, political control of the economy, as market forces were replaced by planning in determining production and consumption. More concretely, however, MININD’s research and development institutes worked towards immediate goals: finding substitutes for costly imports; increasing the value added to raw material exports, particularly sugar and nickel; creating a mechanical industry to exploit Cuba’s metallurgy reserves; producing spare parts and laying foundations for the production of capital goods. Parallel to these projects was the imperative of reducing inequality by extending electrical provision and, hence, employment opportunities, to mechanise agricultural production, raise productivity and create a training infrastructure for future developments. The institutes reflected Guevara’s understanding of which sectors were leading international developments, technologically and economically, while also being grounded in Cuba’s concrete conditions and development needs. Reality imposed many obstacles, as the discussion above demonstrates. When Guevara left Cuba in 1965 the research and development institutes within MININD were neglected. ‘This lasted about two years’, according to Borrego Díaz (2005). ‘It was a mistake on our part, but luckily we realised that quickly and refocused on them.’

There is no space here to discuss Guevara’s legacy, but it would be possible to track the impact of his approach on Cuban development. One example is offered Jorge Ruiz Ferrer, a close collaborating wit Guevara in MININD, including on attempts to apply computer processing to optimise production. After the division of MININD, Ruiz became Vice Minister in the new Ministry of Minerals and Metallurgy where he applied those methods first tentatively experimented with in MININD. Through an investigation into the mining process at Moa using a computer that Guevara had imported from England they saved the country millions of dollars (Ruiz Ferrer, 2006). Ruiz was clear that although substantial results were not attained in MININD, later achievements were the direct legacy of a methodology that Guevara promoted.

While MININD’s achievements were modest, arguably Guevara’s real accomplishment was to introduce a methodology for applying science and technology to production, forcing that agenda onto the national development strategy, initiating the necessary training and research infrastructure, including investing in laboratory research, experimental areas, pilot plants and prototype workshops to create a cycle of innovation. Today, institutes operate in Cuba covering all the areas of those set up by Guevara between 1961 and 1963.

Notes

1. The 1951 report by the Truslow Commission for the International Bank of Reconstruction and Development (IBRD) announced that ‘the Mission could not find any suitable applied research laboratory, public or private, in Cuba’ (IBRD, 1951, p. 223). Cuba’s 1953 census recorded that 60% of Cubans had between three years and no schooling; just over 1% had university education, and only 1.7% of them were science students.
2. US pressure led to the ECLA mission to Cuba being withdrawn in summer 1960.
3. By ‘sucroquímica’ Guevara was referring to chemical derivatives from sugar cane (Sáenz et al., 2003, p. 29).
4. The countryside was populated by rural huts made from sticks and mud; 75% were one room dwellings, with earthen floors, no power or electricity. Only 3% of rural Cubans owned the land they worked while 35% had parasitic diseases (MacDonald, 1995, pp. 48–50).
5. Cuba was paid above world market price for sugar. However, ‘free’ or world market price applied to only 10–15% of internationally traded sugar, the rest being produced to quotas and sold for predetermined prices.
6. Mechanisation could reduce the efficiency and profitability of the sugar industry (Yaffe, 2009, p. 174). Cushion (2016) has details of workers resistance to mechanisation.
7. In mid-1964, Suárez Gayol left MININD to become Vice Minister of Production in the new Ministry of Sugar (MINAZ). In 1966, he went to Bolivia to join Guevara’s guerrilla campaign and was the first Cuban to die there in April 1967.

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Notes on contributor

Helen Yaffe, Dr, is a Senior Lecturer at the University of Glasgow specialising in Cuban and Latin American development. Her doctoral thesis investigated Ernesto ‘Che’ Guevara’s work as Minister of Industries, including his promotion of science and technology and his contribution to socialist political economy debates. It was published as *Che Guevara: The economics of revolution* (Palgrave Macmillan, 2009). She is also the author of *We are Cuba! How a revolutionary people have survived in a post-Soviet world* (Yale, 2020) and co-producer of two documentaries about Cuba, including *Cuba’s life task: Combatting climate change* (2021).

ORCID

Helen Yaffe  <http://orcid.org/0000-0001-9241-4160>

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