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Engineering Leadership

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Engineering Leadership

Mike Murphy and Eugene Coyle

Abstract: By 1921 the American sociologist Thorstein Veblen in his book *The Engineers and the Price System* argued for a technocracy in which the welfare of humanity would be entrusted to the control of the engineers because they alone were competent to understand the complexities of the industrial system and processes and thereby optimize and maximize its output. This chapter sets out to explore the extent to which Veblen's technocratic leadership thesis has come to pass. We first review the role of the engineer in society and in the context of Europe, the US and China, and examine the influence of the engineering profession on the management and economic welfare of nations. Second we review trends in engineering education and formation in Europe, China and the US, and the substantive developmental role of the *Grand Écoles* in 18th-century France. A comparison is made between the economies of Ireland and China, in the context of their recent economic performance. Third a review of commentary on the interconnectedness of world economies and shift in economic power from nineteenth century United Kingdom market dominance to twentieth century United States supremacy and to present day emergence of China as the world's second largest and fastest growing economy, is made in the context of the role of engineering leadership. We finally ponder whether a hybrid political environment, with blending of meritocracy with technocratic leadership and moderated by non-engineering influences, might be a recipe for sustained economic success of nations.

Keywords: technocratic leadership, engineering profession, engineering education, political economy, captains of finance

Introduction

> The material welfare of the community is unreservedly bound up with the due working of this industrial system, and therefore with its unreserved control by the engineers, who alone are competent to manage it.
>
> (Thorstein Veblen 1921, p. 44)

The national economic contexts of Ireland and China in the autumn of 2011 are contrasting and different. China has now become the world's largest exporting nation and its economy (GDP) is second only to the United States in size, at $10 trillion in 2010 figures. The growth rate in GDP has been 8% or higher since the year 2000. On the other hand Ireland has a relatively small economy at $172 billion in

2010 figures, or just over 1% the size of the Chinese economy. Despite recent years of prosperity that were characterised as a *celtic tiger* economy, Ireland went into recession in 2009 as a result of a collapse in the construction sector of its economy. In March 2009 Ireland's economic rating was downgraded from AAA and within twenty months the Irish government requested a bailout from the International Monetary Fund. One estimate puts Irish national debt currently at over €113 billion for a population of just under 4.5 million people, or €25,000 for every person in the country. Irish gross domestic product (GDP) has fallen each of the last three years.

From an Irish perspective, within the space of three short years what was originally characterised as a bank liquidity problem, evolved rapidly into a bank debt problem, progressed to a bank solvency problem and was to become a national debt problem when the Irish government guaranteed all Irish bank debt. It is currently now a national solvency issue because it is not clear that Ireland will be capable of repaying this debt (See, for example, Michael Lewis writing in Vanity Fair (Lewis 2011)).

In Ireland, Irish political leadership allowed the banks and their risk taking to take control in such a way that the bank investors (bond holders) are guaranteed and thus able to walk away from the chaos financially protected while every Irish citizen is required to assume the total debt of the banks. Would a different class of leadership, for example leadership by engineers, have done a better and more honest job of managing the economy? In 1921 Thorstein Veblen argued that the "material welfare of the community is unreservedly bound up with the due working of this industrial system, and therefore with its unreserved control by the engineers, who alone are competent to manage it" (Veblen 1921, p. 44). Perhaps because of the nature of engineering education – at its heart shaping forces to serve some end in an optimal manner – would engineers as leaders have acted more responsibly and demanded more accountability from our captains of finance? Here again Veblen makes the observation that "engineering begins and ends in the domain of tangible performance, and that commercial expediency is another matter" (*ibid*. p. 47).

In a 2005 article Tenner wrote that "The argument that gained credence in 19^{th}-century France and was echoed in other regimes is that a state must be guided by a scientific and technological elite" (Tenner 2005). Certainly modern China would appear to provide a supporting example for Veblen's thesis: the Chinese economy has developed steadily and the majority of its senior political leaders have been educated as engineers. This chapter sets out to explore whether it is the case that modern China, and in particular its leadership, embodies Veblen's technocracy argument and is successful as a consequence; and that Ireland, lacking a discernable technocracy, has suffered as a consequence. We suggest that France provides a western example of a moderating technocracy.

Engineers, captains of finance and investment bankers

From the perspective of a post-first-world-war economy – and the horrors of that conflict must be borne in mind when analyzing his thesis - Veblen observes that the industrial system had become a "system of interlocking mechanical processes" and "an organization of mechanical powers and material resources" and consequently it "lends itself to systematic control under the direction of industrial experts, skilled technologists, who may be called 'production engineers'". Veblen argues that the system, indeed the material welfare of society (specifically "the material welfare of all the civilized peoples") could only function at its best if it is run by engineers all working together harmoniously rather than at cross-purposes in an interdependent manner. "Politics and investment are still allowed to decide matters of industrial policy which should plainly be left to ... production engineers driven by no commercial bias" (Veblen 1921, p.35).

Notwithstanding this, Veblen asserts that statesmen thwart this potential optimality by working to the advantage of individual countries and likewise the captains of finance work at cross-purposes to an optimal system by colluding to benefit vested interests. "It is essential that that corps of technological specialists who by training, insight, and interest make up the general staff of industry must have a free hand in the disposal of its available resources, in materials, equipment, and man power, regardless of any national pretensions or any vested interests" (Veblen 1921, p.35).

Through the industrial revolution there was no separation or division required between industrial experts and those who managed the business. However with increasing complexity and specialization, "progressive differentiation" developed which served to delineate "those who designed and administered the industrial processes from those others who designed and managed the commercial transactions".

Because of increasing complexity, the industrial system came to a branch point with regard to how the system was developed and managed. Greater technical specialization was required to inform production decision making and this required special training, hands-on experience and a focus on technical issues. But by both achieving this training and focussing on technical issues, this ensured that the engineers became the employees of the 'captains of finance' namely those whose role it was to manage the commercial aspects of industry.

> But gradually, with the passage of time and the advance of the industrial arts to a wider scope and a larger scale, and to an increasing specialization and standardization of processes, the technological knowledge that makes up the state of the industrial arts has called for a higher degree of that training that makes industrial specialists; and at the same time any passably efficient management of industry has of necessity drawn on them and their special abilities to an ever-increasing extent.
>
> (Veblen 1921, p. 40)

According to Veblen, technology is a "joint stock of knowledge and experience". Consequently it requires "trained and instructed workmen" and also "a corps of highly trained and specially gifted experts". The development of the education system for these technical experts is described in the next section.

Veblen argues that, in turn, the captains of finance – disparagingly referred to as 'one-eyed captains of industry' - lost control to investment bankers, in part because of the increasingly large scale of corporate enterprise and its necessary financial underwriting through securities. These investment bankers continue to control the technical experts. For our purposes we will characterise this as the expert reporting to the non-expert, a concept that we shall return to shortly.

Up to this point Veblen has developed the argument that without engineers the entire industrial system would grind to a halt and further, that the efficiency of enterprises is significantly compromised by the vested interests of commercial managers and investment bankers. Why then don't engineers, the technical experts, organize into a "self-directed working force"? According to Veblen, engineers have begun to become "class-conscious" in particular as they consider how inefficient the industrial system is, a system of which they are an essential part, but which in no sense is managed for the optimal benefit or needs of the community. They already, but perhaps not fully consciously nor collectively, understood that they controlled the mechanisms of productive industry. The educational system was broadly recognising and responding to the requirements to develop specialized training, acknowledging the importance of the engineers' role. What then if they organised? However, before we can attempt to answer this we must take a step back and provide some context on how the world got to be where it was when Veblen was developing his thesis.

The interconnectedness of the world economy

> The history of the world economy since the Industrial Revolution had been one of accelerating technological progress, of continuous but uneven economic growth, and of increasing 'globalisation', that is to say of an increasingly elaborate and intricate worldwide division of labour; an increasingly dense network of flows and exchanges that bound every part of the world economy to the global system.
>
> (Hobsbawm 1994, p. 87)

Let us review briefly how the world came to be so interconnected. In the latter half of the 19th century, years of industrial development together with free trade policy had greatly benefitted Britain. Its industrial growth had averaged 3 to 4 per cent per annum for most of the century. The outcome of which was that the United Kingdom was the most highly industrialized country in the world. "British export performance in engineering machinery, textiles, iron and steel and coal" made its balance of payments positive, despite the fact that imports of food and raw materials were growing at a faster rate than exports (Robbins 1983). But even at the height of empire, concerns were increasing that technology was mobile and according to Robbins that a "distinctive set of circumstances had produced an industrial revolution in Britain – but it could occur elsewhere. Techniques of production could be mastered by foreigners and there was no reason why they could not improve upon British inventions". As one example, in 1879 Britain produced more steel than the rest of Europe combined. By 1886 the USA had surpassed Britain, followed by Germany surpassing Britain in 1893. Over this period British steel manufacturing continued to grow. But the continued growth in British steel masked the underlying global economic shifts that were taking place. Consolidation and concentration became more frequent within British industry as companies tried to leverage economies of scale and compete against external competition.

By the 4th quarter of the 19th century the United States was booming. During this period many significant technical inventions originated in the USA such as machine tools, the telephone, electrical generation and distribution, and home products such as Singer sewing machines, Yale locks and the typewriter. Bryson has captured this era very well when he writes "Europeans viewed America's industrial ambitions with amusement, then consternation and finally alarm. In Britain, a National Efficiency Movement arose with the idea of recapturing the bulldog spirit that had formerly made Britain pre-eminent. Books with titles like *The American Invaders* and

The 'American Commercial Invasion' of Europe sold briskly. But actually what Europeans were seeing was only the beginning" (Bryson 2010, p. 313). What in fact was occurring was the inexorable shift of economic power and dominance from Great Britain to the United States.

Events at the end of the 19th century have resonances with the economic situation that opened our chapter. In 1890 the British investment bank, Baring Brothers, over-extended itself through bonds to finance Latin American debt and required rescue by the Bank of England.[1] British banks invested heavily overseas in this period with no government interference. The British Government saw its role as trying to ensure fair competition for British business and pursued Free Trade to that end, even when it was clear that British interests were suffering to the ideal of free trade and British bank investments in other countries (Robbins 1983).

In tandem with the technological developments in the United States was the education of engineers and technologists. This was necessary as the United States had pioneered the systematic organization of mass production and skilled engineers were required for factories engaged in design, development and production using scientific principles.

We arrive at a crossroads. As Veblen wrote, the Great War – the war to end all wars – is over. The boundaries of empires are being re-drawn at the Paris Peace Conference in 1919[2]. Monarchies are in upheaval and new political regimes are on the rise. The industrial revolution has yielded to industrialisation and increasingly complex manufacturing processes. The education system is transforming in response. The education of engineers occurs in elite schools. The profession is organising. Has the hour of the *Engineer as Leader* finally arrived?

Economic collapse

It was not to be. The inter-war years were to prove decisively negative for capitalist economies. In describing these years as *the age of catastrophe*, Hobsbawm (1994) has written that "a world economic crisis of unprecedented depth brought even the strongest capitalist economies to their knees and seemed to reverse the creation of a single universal world economy, which had been so remarkable an achievement of nineteenth-century liberal capitalism" (Hobsbawm 1994, p. 7). In short, integration and globalisation of the economies of the world retreated from the outbreak of the First World War. Population migration slowed considerably over this period. "Between 1927 and 1933 international lending dropped by over 90 per cent. ... Each state now did its best to protect its economy against threats from outside, that is to say against a world economy that was visibly in major trouble" (Hobsbawm 1994, p. 89).

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[1] One hundred years later in 1995, the company collapsed through futures trading within the space of a single weekend.

[2] Of interest, a small country called Ireland made representations in Paris to have its sovereignty recognized by the great powers. This recognition was not forthcoming and Ireland went through a war of independence followed by a civil war both of which occurred while Veblen was writing "The Engineers and the Price System".

The end of the Great War provided a temporary boom, but this was short-lived as countries like Great Britain sought to handle approximately 3 million demobilised service men. Unions saw their power increase. However "prices and the boom collapsed in 1920. This undermined the power of labour – British unemployment never thereafter fell much below 10 per cent and the unions lost half their members over the next twelve years – thus once again tilting the balance firmly towards the employers" (Hobsbawm 1994, p. 89). The monetary system collapsed with western countries deflating their currencies in attempts to regain stability. Germany's currency became worthless resulting in its industry becoming starved of working capital and the country relied increasingly on foreign loans. Combined with the burden of £22 billion in war reparations Germany was required to repay under the Treaty of Versailles. This created economic conditions that made Germany receptive to fascism. [3]

Post-war unemployment in most of Western Europe remained extremely high. Unemployment was more controlled in the Soviet Union. Prices for goods continued to collapse, even with stockpiling in attempts to maintain price stability. Industrial output capacity was greater than markets could consume. "At a time when world trade fell by 60 per cent in four years (1929 – 1932), states found themselves building increasingly high barriers to protect their national markets and currencies against the world economic hurricanes, knowing quite well that this meant the dismantling of the world system of multilateral trade on which, they believed, world prosperity must rest." "In a single sentence: the Great Slump destroyed economic liberalism for half a century" (Hobsbawm 1994, pp. 94-95).

Here then is a rationale for the failure of engineers to assume the leadership role argued for by Veblen. The engineers were in a position to optimise efficiency and output at exactly the time when such efficiency and output were counterproductive given the collapse of global trade that was occurring in the world. Consequently, in western capitalist economies, industrial leadership remained with those who controlled output and prices, identified by Veblen as the investment bankers. Experts continued to be managed by non-experts.

The education of engineers in Europe and the US

A brief recall of early developments in engineering education in France and other European countries on the one hand and England and the United States on the other, is important in contextualising the emergence of the engineering profession in Europe and the United States. Context and comparison with the education of engineers in China is addressed in the ensuing section. The emergence and advancement of engineering education through the 18th and 19th centuries is well documented, with scholarly contributions of pivotal historical developments in France, Germany, England, the United States and other western countries (see for example Lundgreen 1990, Belhoste 2007, Gispen 1990).

During the period of the *Ancien Régime* (*Old Order*) - primarily referring to the aristocratic, social and political system established in France from the 15th to the 18th

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[3] Germany fully cleared its First World War debt in 2010 when it made its final payment under the Treaty of Versailles.

century, and up to (and arguably beyond) the French Revolution the word *ingénieur* was synonymous with a state engineer. France had become a centralised state with a strong public service. Various corps of state engineers attained an unrivalled position in French society; "As engineers they lent *technical* expertise to non-juridical matters of public policy; as *state engineers* they rendered *administrative* services and represented true civil servants in the sense of *functionnaires*, while public lawyers lacked this degree of loyalty and ascendency" (Lundgreen 1990, p. 37). From its foundation in 1794, the *École Polytechnique* served as a preparatory school for all state corps. In addition to a solid underpinning in mathematics and science-based subjects, French state engineering graduates were tutored and oriented for careers as state administrators.

The establishment of the *École des Ponts et Chaussées* in France in 1747 may be considered the foundation platform for delivery of formal engineering education in Europe. As described in Bucciarelli *et al.* (2009), students enjoyed the privilege of being state employees whilst receiving a project-centric education under the tutelage of *savant* professors of the *corps.* The latter half of the 18th-century saw the creation of further *écoles*, including the *École des Mines* (1783), the *École de Travaux Public* (1794) – later retitled the *École Polytechnique*, with mission for provision of 'a high intellectual and scientific formation'. This was followed by the *École Centrale des Arts et Manufactures* (1829), offering a more industrial-based education.

The term *ingénieur* was also adopted in Germany in the 19th and 20th centuries, with primary emphasis on military engineering careers. Although there were historical variations in development and orientation when compared to the French model, a similar trend arose through establishment of academies such as the Prussian *Bauakademie* in 1799, providing training for state engineers who served the state through projects and tasks including mining, public works and construction of public buildings and public enterprise projects (Lundgreen 1990).

Formalized engineering education in the United Kingdom had its origin with the establishment of the *Royal Engineering School* at Chatham in 1812. In the United States, the *Rensselaer School* in upstate New York opened in 1823. In Germany, the *Karlsruhe Polytechnische Schule* commenced student training in 1825. In Ireland the first Professor of Engineering was appointed in *Trinity College Dublin* in 1841, while applied technological education commenced with the establishment in 1887 of *Kevin Street Technical School*, the founding nucleus of *Dublin Institute of Technology*.

In the early years of the 20th century, as would be professionals, "German engineers found themselves on the dividing line between the capitalist industry and the old order. With the exception of certain subgroups, engineers never fully succeeded in becoming fully part of either world and ended up being squeezed mercilessly between the two". Gispen considers that the engineers' socio-political failure was related to Germany's industrial successes in the second half of the nineteenth century. "The rift separating *Technik* from *Bildung* and *Besitz* became so deep in Germany that engineers were forced to develop something of a counterculture and compete rather than amalgamate with the dominant social order" (Gispen 1990, p. 2).

In his review of engineering education in Europe and the US in the 18th and 19th centuries, Lundgreen's study on the emergence of "school culture and the engineering profession", proffers that the latter part of the 19th-century was a "major divide in time" in the formation and identity of education across the western world. "The rise to dominance of school culture in engineering education took place much later in England and the U.S.A. than in France or Germany." (Lundgreen1990, p. 1).

The model of engineering education and early formation in England, Ireland and the US had common traits but differed to those of France, and by extension to Germany and other countries in continental Europe. The UK and Ireland developed no elite technical schools, but the education of engineers was taken up by the existing universities. Technical schools were opened towards the end of the 19th century but these developed from the perspective of trades and craft – hands-on engineering – and were not intended to produce elite graduates to assume leadership roles. Broadly in Ireland, England and the United States, there was no corps of public lawyers nor of state engineers (apart from the military) existing which could have provided a role model for civil (meaning "civilian") engineers; with no institutional provision for technical training of engineers in the 18th and 19th centuries. Nor was there institutional training for other professions; universities were essentially liberal arts colleges and schools of divinity. To become a lawyer or physician, with or without college education, one had to be apprenticed. However, professional societies, through a recruitment policy of co-option, provided and "reinforced the network of relationships between pupils and masters". Harvard and Yale were both established in 1847 as schools of applied science, however with greater focus on scientific education than technology. The Massachusetts Institute of Technology (MIT) was created in 1860 with a strategy based on a perceived need of a more technologically applied focused education to that offered by Harvard (Wickenden 1929).

It was only in the latter half of the 19th-century that engineering education in the UK was underpinned by programmes in science and engineering through institutes of higher learning (Bucciarelli *et al.* 2009). Professional engineering bodies had also emerged as custodians of professional training and accreditation in engineering, for example the Institution of Civil Engineers set examinations for qualification of membership to the institution. Coming forward to the mid 20th-century, during the 1940s and 1950s the Rensselaer School in New York subsequently developed along the lines of the Polytechnic, in particular the *École Centrale des Arts de Manufactures* (Wickenden 1929). In this model it is interesting to note that students received tuition in the humanities in addition to their core engineering and scientific studies. Enhanced education in the humanities and social sciences in undergraduate engineering education was advanced with the release of the Grinter Report on the *Evaluation of Engineering Education* (ASEE Report 1956). Grinter acknowledged that many engineers progressed into "managerial and top executive positions in industry and government" and that the "foundation should be laid for an understanding of human relationships, the principles of economics and government, and other fields upon which the engineering manager can build".

The growth and spread of engineering professional organisations occurred in tandem with the establishment of engineering schools throughout the western world in the 19th and 20th centuries and continues today. The Accreditation Board for Engineering and Technology (ABET) sets the standard and curriculum content for engineering and technology programmes in the US. In the UK the Engineering Council is the coordinating body for a host of professional organisations with discipline specific mission. In Ireland, Engineers Ireland is the national institution with responsibility for advancement and accreditation of the engineering profession in Ireland. The *Washington Accord* (1989), *Dublin Accord* (2002) and *Sydney Accord* (2001) are international agreements among bodies responsible for accrediting engineering, technology and technician titles. Under the auspices of FEANI (*Fédération Européenne d'Associations Nationales d'Ingénieur*), the European Accredited Engineer label EUR-ACE was established in 2004 to facilitate accreditation and coordination of standards in engineering programmes throughout the European Union and beyond its boundaries.

Such organisations promote worldwide harmonisation and acceptance through professional recognition of engineering programmes, providing global networking and recognition of the engineering profession. In addition to core staff in the national organisations, volunteer chartered and professional engineers make significant contributions through engagement as committee members and as mentors and advisors to those seeking professional status. The institutions also offer a voice to the members of the profession at national level and on the international stage.

Engineering leadership in Europe and the United States

In Ireland, England and the United States the professionalization of engineering and engineering education fostered a professional developmental channel that diverted engineers away from strictly technology management roles. As noted also by Tenner, "at the turn of the 20^{th} century, U.S. companies fearing manpower shortages resisted attempts to make elite postgraduate degrees the norm for engineers, as they were becoming for lawyers, doctors and executives" (Tenner 2005). Thus for these countries, the lack of elite academies for engineering education, combined with industry pressures to ensure an adequate supply of engineers contributed to the flow of engineers into industry and not into other leadership roles in Ireland, England and the United States.

It is also sometimes argued that engineers, by their education, are blinkered to examine only the technical problem before them and consequently do not see other contextual dimensions, such as societal dimensions, and so whilst they may have optimal solutions they are only optimal with respect to the technical factors they take into account. In discussing the lack of engineers in political leadership roles within the United States, Tenner goes further than this and notes that one explanation may be that engineers "self-select for social distance" and provides anecdotal examples in support of this theory. Interestingly, Tenner refers back to Veblen when he writes "This is an old American stereotype. ... Veblen, championing what was later called technocracy, wrote that "the public considered engineers a somewhat fantastic brotherhood of overspecialized cranks, not to be trusted out of sight except under the restraining hand of safe and sane businessmen". He added, "Nor are the technicians themselves in the habit of taking a greatly different view of their own case" (Tenner 1995).

While commenting in passing that a mix of talented people is ideally what is needed within the context of leadership, nonetheless in Ireland, England and the

United States the task should be to get sufficient numbers of engineers into roles wherein they can interact with and influence other decision-makers[4].

The development of the role of the engineer in China

Let us return now to the question of whether China provides a supporting example for Veblen's thesis that engineers are best positioned to manage the material welfare of the community? Joel Andreas begins his brilliant study of modern leadership in China with the simple statement that "China today is ruled by Red engineers" (Andreas 2009, p. 1). This runs counter to the Marxist vision of a classless society, despite the fact that the Chinese Communist Party (CCP) adopted a Marxist version of socialism. According to Andreas, the CCP was founded by intellectuals but during two decades of armed insurrection it became a party of peasants, which resulted in a rise in peasant leadership. During the early years of communist control in China after the 1949 Revolution, collectivization eliminated private ownership of land and the state took control of large enterprises, with small enterprises being combined into cooperatives.

While it is beyond the scope of this chapter to examine the *Great Leap Forward* from 1958 to 1961 and the subsequent *Cultural Revolution* from 1966 to 1976, what is important to our work is that it was the subsequent reaction to the *Cultural Revolution* that resulted in the creation of a new dominant class led by engineers. Andreas makes the observation that "Mao was completely unsympathetic with intellectuals' conviction that their expertise made them more fit to run the country than the communists." But with Deng Xiaoping's return to power after the death of Mao Zedong, it was those people who were educated at elite technical universities and there received their technical and political training who began moving into positions of power (Andreas 2009). It was at these elite technical universities that they became both *Red* (political training) and *Expert* (studying engineering as an educational discipline). To understand the rise of engineers to dominant leadership positions, it is therefore necessary to understand what it meant to be both *Red* and *Expert*.

Consider first the Chinese Communist Party. Founded in 1921, the Chinese Communist Party (CCP) is the ruling political party of the People's Republic of China (PRC). The CCP maintains a unitary government centralising the state, military, and media. The legal power of the Communist Party is guaranteed by the PRC constitution. The CCP is the world's largest political party, claiming nearly 78 million members at the end of 2009 which constitutes about 5.6% of the total population of China. The CCP is a strongly hierarchical organisation. From the age of nine, children can join the Young Pioneers which is run by the Communist Youth League. At age fifteen, young people can join the Youth League. The Youth League, in turn, is run by the CCP and people can join the CCP at age eighteen. According to An-

[4] Given the collapse of the world economic system in the late 1920's, the argument can be made that had engineers been solely in charge of optimizing industrial output, as argued for by Veblen, then engineers might well have made matters worse by increasing output into deflating national economies.

dreas, this is an increasingly selective hierarchy with more intense competition to gain membership of the Youth League and then the CCP itself[5].

Likewise the Chinese education system was hierarchical and selective. In its first decade of power, the CCP reorganised the school system making it increasingly more difficult to progress from primary school to junior middle school, hence to senior middle school and then on to college. This created tremendous competition among students for increasingly limited numbers of places as they progressed through the education system.

In order to support a program of rapid industrialization, higher education was reorganised along a Soviet model with colleges assigned a specialized teaching mission aligned to a narrow range of disciplines. This facilitated a system to produce large numbers of highly specialized engineers. According to Andreas, between 1947 and 1965 the number of Chinese university students grew by a factor of five (from 130,715 to 644,885) while the number of engineering students grew by a factor of twelve (from 23,035 to 292,680). During the *Great Leap Forward* (1958 – 1961) the Chinese also adapted the Soviet educational model to combine specialized teaching with research and production as elements of the university education, which was retained after the failure of the *Great Leap Forward*. Universities such as Tsinghua continued to stress the importance of hands-on learning and ensured that its students learned technique rather than simply engaging in manual labour as part of the curriculum.

The CCP "created a highly centralized, hierarchical and meritocratic education system" while at the same time it was "resolutely committed to eliminating class differences based on education". This paradox caused difficulties in the period between the 1949 Revolution and the Cultural Revolution in 1966. The CCP used slogans such as *politics takes command* to argue that experts should be subordinated to political leaders. But the reality was that "poorly educated Communist officials were attempting to supervise non-Communist experts" so that despite having authority they lacked technical understanding to provide leadership. While at a micro level we can characterise this in a Veblen-style argument that experts were being managed by non-experts, at a macro level the *Great Leap Forward* was a disaster for China as the attempted expansion of its industrialisation failed and millions starved to death.

To address this problem the CCP realized that the "long-term solution was to train a new generation of cadres who had expertise and were also committed Communists, that is, cadres who were both Red and expert" (Andreas 2009, p. 50). As recounted by Andreas, in 1958 the President of Tsinghua University, Jiang Nan-

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[5] The primary organization of power in the CCP comprises the Central Committee which includes (a) the Politburo Standing Committee, which currently consists of nine members; (b) the Politburo, consisting of 24 full members (including the members of the Politburo Standing Committee) and one alternate; (c) the Secretariat, the principal administrative mechanism of the CCP, headed by the General Secretary of the Communist Party of China; and (d) the Central Military Commission (a parallel organization of the government institution of the same name). The Central Committee has approximately 370 members, including ministers and senior officials in Beijing and leaders of provincial governments and cities in addition to senior military personnel. The current membership of the Politburo Standing Committee includes Hu Jintao, President of the Peoples Republic of China and Chairman of the PRC Central Military Commission, and eight senior party members.

xiang, addressed the collected students and teachers of the university and said: "Our requirement for training cadres is that they become both Red and expert. If you are not thoroughly Red and deeply expert, that is a huge waste". Seven years later in 1965 Jiang addressed the incoming students to Tsinghua and told them that in the future China would be run by engineers, and that since Tsinghua was the leading engineering school in China, it was likely that some of these incoming students would become national leaders. Later in 1978, after Deng Xiaoping came to power and was rehabilitated, Jiang was appointed Minister for Higher Education. Finally in 1980 Deng himself addressed the assembled body of Tsinghua University and declared that "expertise does not equal Redness, but Reds must be experts." This spelled the end of the class-levelling aspects of Mao's policies and established a new class who held both Red and expert credentials and who were rapidly promoted into leadership positions. A significant feature of the CCP's Politburo Standing Committee today is that eight of the nine elected senior officials trained as engineers. This contrasts with the largely legal profession political leadership in both Europe and the US.

The result of the political and educational structures established was that CCP members who were students in elite technical universities had come successfully through two separate, distinct and rigorous selection processes: one to gain membership of the CCP and one to become a student at an elite technical university. Andreas also notes that job assignments for graduates corresponded with the rank of the university and so graduates from top-ranked universities such as Tsinghua University in Beijing "received prized assignments in national and provincial government offices, industrial ministries, large industrial enterprises, research institutes and universities". This of course was possible because of the collectivization policies implemented after the Revolution in 1949 allowing the government to place whomever it wanted wherever it wanted across the industrial sphere. From the perspective of Veblen, this is a centralised version of the engineers-in-control that he advocated. Therefore these graduates had the additional characteristic of post-university roles that provided them with considerable responsibility and experience. It is interesting to note here the strong parallels with the "selection, streaming and differentiated experience" discussed at length by Gladwell in his popular book *Outliers* to explain those people who become successful in sports and which Gladwell uses to set the framework for success in other human endeavours (Gladwell 2008).

A transformation in ideological thinking occurred in the post-Mao period as a logical consequence of accepting the requirements to be both Red and expert. During the Mao era, party leaders were not university educated, but instead came from the ranks of the masses. Post-Mao, *Red and Expert* meant that engineers were now considered to have the best qualifications to be administrative and political leaders and this has naturally resulted in people educated as engineers discharging non-engineering roles.

In addition to coming successfully through the two separate rigorous selection processes of education and CCP membership, followed by prized government roles for graduates, these graduates also benefitted from maintaining a network of fellow graduates from elite Chinese universities. This is particularly true of Tsinghua University. As Li notes, "Indeed, there is no more telling example of the role of a school network in the rise of technocratic elites in post-Mao China than in this institution" (Li 1994, p. 2).

A further significant advantage enjoyed by CCP members who graduated in engineering from elite universities was the school networks they developed and maintained. Writing in 1994 Li noted the importance of political networks developed at Tsinghua University: "Some China experts believe that technocratic elites lack close interpersonal ties or political networks, and that technocrats come to power mainly because of their technical expertise. Yet a careful analysis of the biographical backgrounds of Qinghua technocrats shows that their political networks at Qinghua are more important than technical expertise for explaining their success in acquiring leadership posts" (Li 1994, p. 2). In echoing what has had been said of elite schools in other countries such as Harvard or Yale, Li states that "belonging to an elite school network is far more essential for politicians than having an elite university degree. Intelligence and skills facilitate career advancement, but connections, or *guanxi*, are what really count" (*ibid*, p. 2-3).

Conclusion

This chapter began with a brief comparison of the relative position of two very different economies, those of Ireland and China in 2011. We asked the hypothetical question: *What if Ireland had been lead by engineers, would it have avoided the difficulties it now faces*? To provide a framework to examine the role of engineering leadership we took as our starting point the arguments developed by Thorstein Veblen that engineers were ideally positioned to assume and assert greater control over the mechanisms of production. However Veblen wrote in 1921 just after the Great War and this turned out to be a critically important period in global economic development. For what occurred in the 1920's – and has subsequently been characterised as the period between the two world wars – was an economic collapse on a global scale. This collapse fundamentally re-shaped the remainder of the 20th century, including the possibility of an enhanced role for engineers in leadership roles.

We have seen that a system evolved in Ireland in which there are no elite engineering academies, and no mechanisms to ensure a steady stream of highly qualified engineers into key leadership and influencing positions[6]. This contrasts directly with China wherein the CCP afforded status to engineers and scientists, and the combination of membership in the CCP, access to elite engineering universities, key government roles after graduation and the support of old school networks all combined

[6] There are exceptions to the rule. Looking back over several decades at deputy and ministerial posts in the Irish Parliament there is perhaps only one entry of a senior ministerial post held by an internationally renowned engineering academic. Tribute was paid by UNESCO-IHE Institute for Water Education in August 2008 upon the death of Professor James Clement Dooge:
'Professor Dooge (1992-2010) was an Irish hydrologist, politician, engineer and academic. He lived a multifaceted existence with his roles including a period as Irish Minister for Foreign Affairs, Chairman of the Irish Senate, President of the International Council for Science, President of the International Association of Hydrological Sciences and Professor of Hydrology at Dublin University. He had a significant role in the development of the European Union during the Irish presidency of 1984' (UNESCO-IHE).

to ensure that engineers dominate political and industrial leadership in modern China.

However, there is a critical point to be made with regards to China and its development and which links back to the framework for this chapter. First, other eastern European communist states adopted a technocratic leadership regime. To achieve this they re-structured their higher education system into specialised schools. What China did differently, is that it reacted against Mao and the Great Leap Forward, which attempted to make experts (i.e., engineers) subservient to Reds (i.e., political party cadres). When the Great Leap Forward failed spectacularly with estimated millions upon millions of people dead, China moved to implement a meritocracy combined with a technocratic, centrally-controlled party leadership regime. It was the meritocracy combined with the highly competitive and highly selective system that ensured that only those people who were capable of getting through the rigorous party selection process and succeeding in the leading engineering universities such as Tsinghua University ended up in key government-designated jobs.

Perhaps Cheng Li (1994) captures the point best and links it back to Veblen as follows. "In the classic writings on technocracy, technocrats are usually portrayed as people who are interested not in power but in technical matters. They are selected not because of their political associations but because of their technical expertise. China's experience is different". Li goes on to argue that "The selection of Chinese technocrats, therefore, is not based on criteria which are universalistic, scientific-technical, or impersonal, but is conditioned by the political and institutional network through which they have been promoted. China is entering a new era in its century-long modernization process. A new generation of leadership, a technocratic elite, is moving toward the centre stage of Chinese politics" (Li 1994).

What China appears to have proved (perhaps inadvertently) was that a Marxist classless society could not succeed if that society wished to be a successful industrialized nation. The reason is that technocrats must be capable of exercising the skills that they have developed through their education and be empowered to manage those without such skills. Mao saw the experts as a class of intellectuals - and he fought hard to suppress them and ensure that the CCP was not controlled by them, and indeed that uneducated peasant cadres were in charge of production. This is Veblen again, but from a different perspective. Veblen argued that it was the one-eyed "captains of industry" to blame, and then the investment bankers. But substitute "non-expert party cadres" for captains of industry and Veblen's argument is made from a Chinese perspective. Therefore it is in modern China that we find evidence of Veblen's central argument.

The situations in each country are unique to that country and it would be unwise to draw generalisations from their individual circumstances. For example, in China the authoritarian, single party system was a necessary ingredient because it ensured that the system was implemented; and collectivization ensured that the engineering graduates received important industry and government jobs. This worked in China and for China at a particular point in its history, but even now it is changing as more non-engineers move into positions of power and the privatization of assets continues in China. But if one were to generalise, a hybrid environment blending meritocracy with technocratic leadership moderated by non-engineering influences might well be the recipe for a successful country.

One question that remains as we close this chapter: are there parallels between the shift in economic power from the United Kingdom to the United States at the end of the 19th century to the shift in economic power from the United States to China at the start of the 21st century? Further, given the current global economic difficulties which exist, particularly in the United States and Euro-zone countries, are there parallels with the Great Depression of 1929 – 1933?

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