A case study on the adoption of metric system in Australia:
A technological change brought about by
social and economic factors

Australia's conversion to the Metric System of Weights and Measures from 1970 to 1981

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1. INTRODUCTION

Conversion to the metric system was one of the major technological developments in Australia from 1970 to 1981. This technological change influenced Australian society and culture especially in exchange of goods and services.

This case study aims to analyse the influences of social and economic factors which brought about the effective implementation of the metric conversion in educational and commercial sectors. The focus is limited to the units of length and weight implementation of metric.

The analysis is based on three theories from the field of the social studies of technological development. The first theory states that, technological development occurs not as an isolated event but as part of a larger system called socio-technical systems (Hughes, 1969, cited in Mackenzie and Wajcman, 1999, p10). The decision to metricate was brought about by various representatives in Australian society, not only by a government mandate or advice from industry experts'.

The economic factors that influenced the decision to convert into metric system will be evaluated against the second theory which states that technological decisions are economic decision (Mackenzie and Wajcman, 1999, p12). Analysis using this theory is significant because among other factors which caused Australia's businesses to flourish, metrication made Australian product specification (i.e. dimension and weight) compatible with the rest of the world (Appendix 3). However, in retail trading, there were economic factors that served as resistance to this change; these are called reverse salient in technological development (Hughes, 1983, cited in Mackenzie and Wajcman, 1999, p11) - the third theory for analysis.

The units of time and temperature among others (see Appendix 4 for a complete list) which remain non-SI are not part of this case study because their non-conformance neither serve as barrier to trade nor propose risk to health and environment (Walsh, 2002, p8) . Also, this case study will not include the conversion process in the areas of manufacturing, science, industry (building construction, transportation, aviation and the like), and government regulations. Furthermore, the development and process of standardization, physical standard artefacts (i.e., platinum-iridium bar, Krypton 86 radiation, column of mercury etc.), regulation of standard practices and technicalities of SI conversion are also not within the scope of this case study.

2. BACKGROUND

2.1 Brief history and development of International System of Units (SI)

On May 20, 1875, representative from seventeen countries convened a meeting in Paris and signed the Metric Treaty (Wright , 1998. pg1). This 1875 convention also led to the establishment of the International Bureau of Weights and Measures (BIPM), the purpose of which was, to ensure worldwide unification of physical measurements. Furthermore, during this convention, the constitution of the General Conference on Weights and Measures (CGPM) was established to handle all concerns regarding the metric system worldwide (IEEE and ASTM, 1997, pg. 60). A series of convention of CGPM was organized at least every six years starting from its conception in 1875. Through CGPM, improvements on measurements system have been developed (IEEE and ASTM, 1997, pg. 60). From the imperial system, metrication evolved into CGS (centimetre-gram-second) system in 1881, MKS (meter-kilogram-second) system in 1900, MKSA (meter-kilogram-second-ampere) system in 1935, MKSA plus Kelvin and candela in 1954, and last but not the least, the full SI title in 1960 (Appendix1). Then, more and more refinements occurred until the 20th CGPM in 1995 (IEEE and ASTM, 1997, pg. 60)

2.2 A glimpse of Australia's measurement system for length and weight before 1970

Before 1970, in Australia, length and weight were measured using the imperial system of measurements (Appendix2). The imperial system of measurements for length was based on human proportions (Gatfield, 1999). These measurements varied greatly and lacked uniformity. For instance, prior to 1958 the IMPERIAL INCH measured 2.54cm in Australia, 2.540005cm in the U.S.A. and 2.5399956cm in the U.K. (Gatfield, 1999). This system presented a major technical deficiency, because to calculate lengths, areas and volumes for example, measurements in feet and inches, had to be converted to a decimal number in a single unit before they could be used for computation.

For weight, there were three Imperial measurement units: the AVOIRDUPOIS, APOTHECARIES and TROY (Gatfield, 1999). The avoirdupois weight system was the standard in Australia, prior to the Metric conversion in 1970, but the official international price and weight of gold then and now has been measured in U.S. Dollars per Troy Oz (12 Troy Oz = 1 Troy lb). The lesser known Apothecaries system was widely used by chemists and pharmacists, for the compounding and dispensing of drugs and medicines (Gatfield, 1999). It was confusing to compare measurement made in these three units because even if the apothecaries' ounce was equal to the troy ounce, neither was equal to the avoirdupois ounce (Gatfield, 1999).

These inconsistencies in measurements of length and weight, among others, were some of the factors why Imperial system was claimed to be less practical to use than Metric system. That is why in April 1967, a Senate Select Committee (SSC) was formed in order to research and determine the practicability of the conversion from the Imperial to the Metric system. The SSC gathered facts and evidence from 141 witnesses and held 67 meetings in all capital cities (Reid, 2002, p1). SSC solicited written submissions from Commonwealth Ministers and Departments, Commonwealth State Instrumentalities and organizations and from individual citizens who were confident in the use of metric system. The result of this process was a unanimous opinion among those who participated in the research that conversion solely to metric system was practicable and desirable, despite the fact that Imperial system served as de facto standard for quite some time (Bowen, 1970, p1).

2.3 Government and industrial bodies responsible for Australia's metrication process

The Government's decision that Australia should convert to metric system as early as possible was publicly announced by the Prime Minister (Mr. Gorton) on 19th January 1970 (Bowen, 1970, p1). The Metric Conversion Act was passed by Parliament on January 1970 and in the same month the Metric Conversion Board (MCB) was set up. The MCB was composed of committees, sub-committees and panels, wherein its 160 members were nominated by the industry experts. MCB was charged of the implementation and could decide without any prior approval from any other body (Reid, 2002, p1). Thus, in this way MCB had executive responsibility.

Any industry or group converting to metric system would find it beneficial if they have fullest consultation and cooperation with MCB (Reid, 2002, p1). For example, under the MCB, the conversion of consumer goods and services into metric units was organized by the Consumer Goods and Services Industries Advisory Committee and the sector committees like the Clothing Sector Committee, Meat Products Sector Committee, Personal Services Sector Committee, Soap Industry panel, and Working Party for Retail Scale Conversion in NSW, just to name a few (Wilks, 1982, p52).

2.4 Factors that Influence Australia's decision to convert into metric system

The conversion to metric system was predominantly a technological change brought about by the recommendations from different sectors of society. One of the main factors why this technological change was significant, was the fact that 90% of the world population (appendix 3) was using the metric system and its use was continuously increasing. Also, 75% of world trade was being carried out using the metric system (Wilks, 1982, p10). Other major factors which influenced the adoption of metric system were simplification and unification of the teaching of mathematics and science, reduction of variety of production materials, and dissemination of knowledge was assured due to a large body of people who came to Australia had been using this system in their native land. Moreover, even though it was understood that there would be significant costs in the conversion process, these costs were intended to be minimized by careful planning and the benefits of conversion would outweigh any disadvantages that maybe suffered during the period of transition (Bowen, 1970, pg3).

2.5 Metrication of consumer goods and services

Among several considerations on the metrication program in Australia was its influence on general public. The ordinary people had the maximum exposure to this technological change and therefore had the opportunity to experience the use of metric units through the purchase of foodstuffs, packaged goods, clothing, household goods and services. Greater impact would be on older Australians who had been using the Imperial System since childhood. Thus, the MCB and the committees tried their best not to depart from the established practice while the transition from Imperial System to Metric System for clothing, garments, dairy products, beverages, and precious metals was being carried out (Wilks, 1982, p63-67).

For example, metric conversion for clothing and for garments, led to the establishment of uniform size coding. For a number of years, the sizes were labelled with a numerical code. The numerical code then, remain unaltered, instead, just the measurements related to that size have been expressed in centimetres. Moreover, it was agreed by industry representatives that textiles be sold in metre or tenths of a meter, which closely resembled the previous practice, yards and eights of a yard (Wilks, 1982, p63-67).

For dairy products, by March 1974, all pint bottles were replaced by 200ml, 300ml, 600ml, 1Litre and multiples of 1 Litre for milk. For butter, it was 125gram, 375g and 500g. This was done because it was usual practice to use multiple of the minimum amount to arrive at the next bigger amount. For instance, to have 500gram, multiply 125g by 4 or 600ml is 3 times of 200ml. By early 1976, all other packaged dairy products like cream, cheese and milk powder were sold solely in metric quantities (Wilks, 1982, p63-67).

For beverages, it was in SA and WA in 1971, when metric marking of beer had begun. It was by the end of 1972, when Eastern States had completed their metric conversion of bottled beer. Although, by the end of 1980, some spirits were still measured in imperial units (1 fl oz = 28.4ml), discontinuance of its use was sought because SA, NT and VIC had completed the conversion to sole metric measures for spirits already (Wilks, 1982, p63-67).

For precious metals, retail sales were smoothly converted into grams because at that time, there was confusion already between the use of imperial units, troy ounce and avoirdupois ounce. However, ingots were still sold in bullion market using troy ounce bars or kilogram (Wilks, 1982, p63-67).

Despite all the significant influences that metrication provided to different sectors, the conversion process took place not all at once in all regions but instead the adoption was done state by state, for some adoption was voluntarily and for some, no adoption at all (Wilks, 1982, p97).

The fear of some retailers to lose sales if other retailers did not abide with the conversion at that time caused retailers to remain in Imperial System, thus unfair competition arose. The MCB then, decided to implement conversion state by state to address unfair competition. Additionally, the conversion had been more efficient and more economic because the authorities responsible for implementation were concentrated in areas zoned (Wilks, 1982, p97).

Others converted voluntarily and others not at all, because under consumer goods, not all items could be converted to metric with strict regulations. Not following regulations to metricate was acceptable because of the following three reasons; non-conversion to Metric System did not serve as barrier to trade, non-conversion did not propose risks to life and environment and conversion to metric was impractical and uneconomical in any way (Walsh, 2002, p8). For instance, in hospitals and baby health centres, for safety purposes, all milk formula preparation and feeding bottles were in metric by import regulations but in furniture industries conversion of its venetian blind rods and awnings in centimetres for quotation were voluntarily. Another example was in footwear industry, that time and even today footwear industry uses different number of sizing systems (British, American Fractional Fitting and Continental Systems) because shoes suppliers were diverse and therefore one sizing system was impractical. Nevertheless, the rubber thongs which were in inches were converted to centimetres because its non-conversion would result to different tolerances and therefore was a barrier to trade (Wilks, 1982, p97).

2.6 Metrication as an economic decision

International standards were becoming more important because world trade was becoming more competitive (Walsh, 2002, p8). By removing the obstacles to exporting that resulted from disparities between Imperial System and International standards (SI or metric system), the harmonization, or bringing into agreement, of standards would significantly improve Australia's global competitiveness. Thus, MCB and other committees' plans to meet legislative requirements, preserve Australia's export markets and meet consumer needs supported the said harmonization through metrication of consumer goods and services (Wilks, 1982, p52).

The acceptance of common metric measurement language (SI) worldwide (Appendix 4) created an opportunity to modernize industrial standards, reduce present uneconomic proliferation, and facilitate world trade. This was true not only in Australia but most of all in the U.S. In fact, as just one example, the Industrial Fasteners Institute estimated savings over US$500 million per year to U.S. product users if their Optimum Metric Fastener System with 25 thread sizes was adopted instead of ABC Unified System with 59 thread sizes (McClure and Pearson, 1973).

3. ANALYSIS

According to Hughes, the coordination and alignment of each component in a technological system is needed for the successful implementation of any technological change (1969, Mackenzie, and Wajcman, 1999, p10). In this case study, there was a consensus to metricate among different government agencies, the commercial, industrial and educational sectors, as well as a significant number of ordinary people. This brought about the successful adoption of metric system in clothing, beverages, dairy products and precious metals in Australia. However, some items did not adopt Metric System right away and others did not convert at all.

Hughes defines reverse salients as a product of uneven development, an area where growth of technology is seen as lagging behind (1969, cited in Mackenzie, and Wajcman, 1999, p11). The unfair competition came about when some retailers remained in Imperial System because of their fear of losing customers due to metrication. Thus, unfair competition was an economic factor identified as a reverse salient to this technological change. MCB did address the unfair retail competition by focusing on the conversion state by state. Other reverse salients identified are those which did not metricate due to either non-conversion is not a barrier to trade, do not propose safety issues or not practical and not economical in any way, like shoes sizing system and selling ingots in bullion market.

Australia's international trade relations and local exchange of goods were also the drivers of this change. The technological decision to metricate was also an economic decision. Conversion of consumer goods such as clothing, garments, dairy products, beverages, and precious metals from Imperial system to Metric system gave way to acceptable international exporting and importing capabilities of Australia. This moved reduced the cost for repackaging and repricing in the otherwise non-metric system. Thus, this is an example of what neoclassical – economists used to say, that technology and economics are inseparable (Mackenzie and Wajcman, 1999, p13).

4. CONCLUSION

It can be concluded from this case study, that a successful implementation of any technological change is possible if social and economic factors work favourably to this change. The MCB together with all the agencies and ordinary individual harmoniously cooperated and supported this metrication program.

Furthermore, the need to identify and address any reverse salients in any given technological development should not be ignored; otherwise it will either slow down or totally hinder its implementation.

Australia’s metrication program is a valuable example and model of a successful technological change. Australia’s metrication was a technological change where each component of the socio-technical system worked favourably towards a common goal. Australia’s metrication was both a successful technological decision and an economic decision.

5. REFERENCES

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6. Appendices

Appendix 1:*Reproduced from: http://www.metric.fsworld.co.uk/sibasis.htm, accessed 01/04/03*

THE SEVEN SI BASE UNITS

Quantity	Name	Sym	Definition (CGPM)
length	metre	m	The metre is the length equal to 1 650763,73 wavelengths in vacuum of the radiation corresponding to the transition between the levels 2 p_{10} and 5 d_5, of the krypton-86 atom.[11th CGPM (1960), Resolution 6.]
mass	kilogram	kg	The kilogram is the mass of the international prototype of the kilogram recognised by the CGPM and in the custody of the Bureau International des Poids et Measures, Sevres, France. [1st CGPM (1889).]
time	second	s	The second is the duration of 9 192631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium-133 atom. [13th CGPM (1967), Resolution 1]
electric current	ampere	A	The ampere is that constant current which, if maintained in two straight parallel conductors of cu rrent infinite length, of negligible circular cross-section, and placed one metre apart in vacuum would produce . between these conductors a force equal to 2 x 10-7 newton per metre of length. [CIPM (1946), Resolution 2, approved by the 9th CGPM (1948).]
thermo-dynamic temper-ature	kelvin	K	The kelvin, unit of thermodynamic temperature, is the fraction 1/273,16 of the thermodynamic temperature of the triple point of water. [13th CGPM (1967), Resolution 4]
amount of substance	mole	mol	The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0,012 kg of carbon 12. [14th CGPM (1971), Resolution 3.]
luminous intensity	candela	cd	The candela is the luminous intensity, in the perpendicular direction of a surface of 1/600000 square metre of a blackbody at the temperature of freezing platinum under a pressure of 101 325 newtons per square metre. [13th CGPM (1967), Reso'n 5.]

In 1960 the Conference Generale des Poids et Mesures (CGPM), which is the international authority on the metric system, accepted a universal, practical system of units and gave it the name Le Systeme International d'Unites with the abbreviation SI. Since then this most modern and simplest form of the metric system was introduced throughout the world and by 1970's more than 20 countries, including established metric countries, passed legislation adopting the SI system as their only legal system with numerous countries following their example.

Appendix 2: *Reproduced from: http://www.ijc.com/imperial.html, accessed 16/04/03*

The U K (Imperial) System of Measurements

Length

12 inches = 1 foot
3 feet = 1 yard
22 yards = 1 chain
10 chains = 1 furlong
8 furlongs = 1 mile
5280 feet = 1 mile
1760 yards = 1 mile

Area

144 sq. inches = 1 square foot
9 sq. feet = 1 square yard
4840 sq. yards = 1 acre
640 acres = 1 square mile

Volume

1728 cu. inches = 1 cubic foot
27 cu. feet = 1 cubic yard

Capacity

20 fluid ounces = 1 pint
4 gills = 1 pint
2 pints = 1 quart
4 quarts = 1 gallon (8 pints)

Mass

437.5 grains = 1 ounce
16 ounces = 1 pound (7000 grains)
14 pounds = 1 stone
8 stones = 1 hundredweight [cwt]
20 cwt = 1 ton (2240 pounds)

Troy Weights

24 grains = 1 pennyweight
20 pennyweights = 1 Troy ounce (480 grains)
12 ounces = 1 Troy pound (5760 grains)

Apothecaries' Measures

20 minims = 1 fl.scruple
3 fl.scruples = 1 fl.drachm
8 fl.drachms = 1 fl.ounce
20 fl.ounces = 1 pint

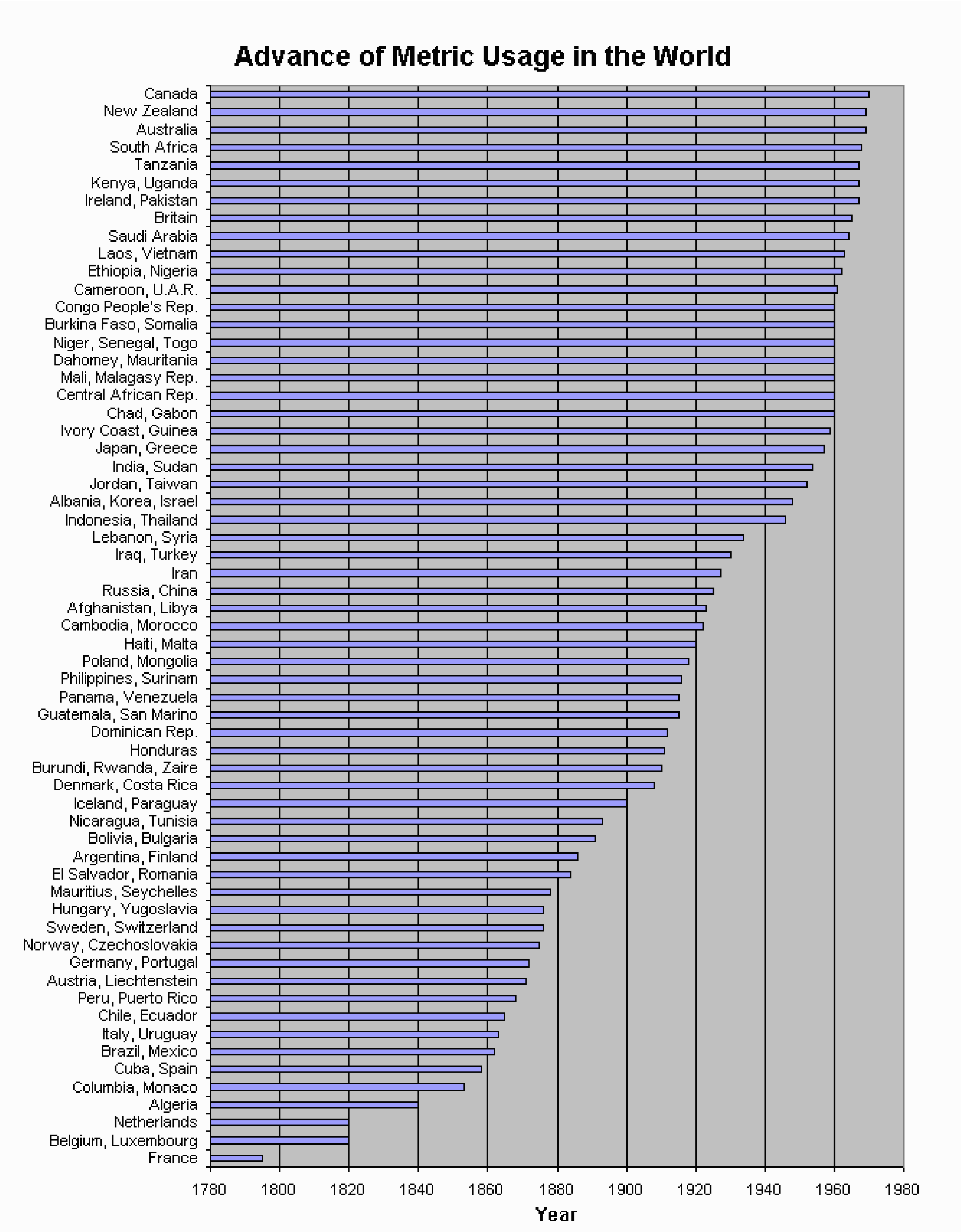
Apothecaries' Weights

20 grains = 1 scruple
3 scruples = 1 drachm
8 drachms = 1 ounce (480 grains)
12 ounces = 1 pound (5760 grains)

The old Imperial (now UK) system was originally defined by three standard measures - the yard, the pound and the gallon which were held in London. They are now defined by reference to the S I measures of the metre, the kilogram and the litre. These equivalent measures are **exact**.

1 yard = 0.9144 metres - same as US
1 pound = 0.453 592 37 kilograms - same as US
1 gallon = 4.546 09

Appendix 3: *Reproduced from : Reid, J.B., 2002, Metrication of Australia, U.S. Metric Association (USMA) website, http://lamar.colostate.edu/~hillger/internat.htm (13/04/03)*



Appendix 4: *Reproduced from:*
http://www.ac.wwu.edu/~vawter/PhysicsNet/SymbolIndex/SIUnits/UnitNonSI.html
accessed (21/05/03)

Some common Units that are NOT SI

Quantity	Name	Symbol
time	minute	min
time	hour	h
time	day	d
plane angle	degree	°
mass	metric ton	t
volume	litre	l
energy	electron volt	eV
speed	kilometre per hour	km/h
area	hectare	ha
temperature	degree Celsius	°C
rotational frequency	revolution per minute	r/min

Non SI unit	Unit type	SI conversion	Notes
liter (L)	volume	1 L = 1000 cm^3	1 quart = 0.946 L
Angstrom (Å)	length	1 Å = 10^{-10} m	typical radius of an atom
atomic mass unit (u)	mass	1 u = 1.66054 x 10^{-27} kg	about the mass of a proton or neutron; also known as a 'dalton' or 'amu'