

Chapter 11

WEAPONS OF MASS DESTRUCTION AS MATURE TECHNOLOGIES

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The General Argument

Weapons of mass destruction are products of industry and, as such, are subject to the same broad forces as other products of industry. These include technological maturation. By this I mean not simply 'age' but rather certain specific processes that can occur over time. These have implications for non-proliferation regimes, indeed they have been at work for some time and specific regimes are attempting to cope with them on a specific basis.

What are some of these effects and their implications?

The concept of technological maturity argues that technological innovations – whether products or related production technology – go through cycles of development, absorption, and standardization, which are related to the diffusion of that technology. At the start of an innovation cycle, for example, a new technology – a product or a process – may be highly inaccessible, or it may open up the possibility of entry by radically altering the difficulty of production or reducing the requirements needed for production. This latter is one possibility lurking in the biological sciences as regards biological warfare. As a technology ages, however, certain specific processes work that can lower barriers to entry into production, creating possibilities for entry by new producers.¹

For example, as time passes, the scientific and technical knowledge that lies behind an innovation will spread, and will increasingly enter the public realm. The leading edge of science becomes the commonplace of university classrooms, papers get published, patents expire, information gets declassified, licensing agreements are signed, and ideas are stolen. Thus, for any potential producer, the cost of acquiring the requisite scientific-technical knowledge declines. Experience in production also erodes as a barrier, as engineers become more familiar with the product or the processes and the principles underlying it, and as trades develop the relevant skills and equipment.

1. For a specific examination of technological maturity and barriers to entry, see Carlota Perez and Luc Soete, "Catching up in technology: entry barriers and windows of opportunity", in Giovanni Dosi *et al.* eds., *Technical Change and Economic Theory*, (London: Pinter Publishers, 1988), 458-479.

Locational advantages decline – unique combinations of people, services, financial resources, raw materials and the like become replicable. As well, by the end of the cycle, the product itself may be in a relatively final form, although there may be great changes in detail that could enhance its performance as compared to earlier versions. At an extreme, it may become simply a standardized commodity, in which producers compete for sales simply on the basis of price. The same can be said for production techniques as well, although here innovations could change things on the level of detail.

As these barriers to entry decline, new producers can enter a market – both states and firms within states. Suppliers of products and of specific components or elements within a given production chain multiply. Another aspect of technological maturation is that technology – the product or even individual steps in the production process – that was once available only as a package becomes increasingly subject to disaggregation: it can be dissolved into its components, or even sub-components and these may then be acquired separately and recombined by the purchaser. Thus, the manufacturer of a final product may find itself able to make many components or sub-components itself, or to buy these from more suppliers. It may also be able to acquire or produce, and assemble itself, components and sub-components at further removes from the production chain for the intended final product. The effects of maturation may be felt not only along the production chain of immediate interest but also in the means of producing the individual links in that chain. Finally, the broad production processes and skills, and the materials, may become deeply embedded in the normal civilian economy of a state, such that it becomes difficult to disentangle either the weapons potential of the technology or even its possible actual development from the background of legitimate civilian use. This is the problem of ‘dual-use’ technologies with a vengeance.

One barrier to entry does **not** decline in this model: the minimum fixed investment required to enter production. This cost, in fact, increases. This problem, however, is not necessarily applicable to our purposes. The rise in the necessary minimum fixed investment is related to arguments about economies of scale and the need to meet competition which is increasingly price-based. Potential and actual producers in a market are driven to adopt increasingly efficient and large-volume production methods to achieve large runs at a low per-unit cost. If one is not producing for a market, however, this factor tends to fall off. Indeed, the need to adopt the latest, or the most economical, methods may disappear entirely: all one needs is the combination of production methods necessary to make a product which, even if not the last word in sophistication, is good enough to do the job required.

As an example, the Iraqi chemical weapons programme has been described as the weakest and the worst-organized of its efforts in the production of weapons of mass destruction, with “poor quality nerve agent, badly designed

munitions, production problems, and cavalier attitudes to safety....”² These problems did not prevent the Iraqi government from producing and using chemical weapons, in large volumes and with the apparent desired effect overall, against Iran and against its domestic foes.

Technological maturation is thus a generic factor operating to produce a variety of effects already noted in specific areas of non-proliferation. These include:

1. the multiplication of potential and actual suppliers, of components, sub-components, processes, materials, and means of producing the means of production (the production chain) of weapons of mass destruction, both foreign and domestic, and at both a national and a sub-national level;
2. the consequent difficulties in organizing and managing supply control efforts in a non-proliferation regime;
3. the increased ability of states to acquire ‘weapons options’ as a mere function of the spread of technology;
4. the increased ability of a state wishing more than a broad ‘option’ attendant upon possession of a civilian capability to acquire the more specific components and production processes piecemeal and clandestinely, to supply some of its needs itself, and to assemble the various components into a serviceable final product; and
5. the consequent difficulty facing non-proliferation regimes in ensuring that clandestine acquisition and production programmes, whether or not in violation of specific obligations, are checked or at least hindered.

In applying the concept of technological maturation,³ I found that the chemical and biological areas were closest to the situation of technological maturity. In these areas, basic information, equipment and materials may be fairly readily available, and the relevant technology may be particularly embedded in civilian industry. Nuclear weapons were somewhat less mature, but, at least for the plutonium route, a crude production reactor is feasible, while reprocessing has been declassified since the 1950s. Long-range ballistic missiles fit least well into this end of the innovation cycle, but shorter-range missiles were a closer fit. A number of states – North Korea being recently the

2. John R. Walker, “The UNSCOM Experience: Orientation”, in Steven Mataija and J. Marshall Beier, eds., *Multilateral Verification and the Post-Gulf Environment: Learning from the UNSCOM Experience*, (Toronto: Centre for International and Strategic Studies, York University, 1992), 91.

3. The results of this investigation are found in James Keeley, Nancy J. Pearson-Mackie, and Shawn MacWha, “Weapons of Mass Destruction as Mature Technologies: Implications for Control, Verification and Confidence-Building”, a report prepared for the Verification Research Unit of the Department of Foreign Affairs, November 5, 1993.

most notorious of these – have been able to produce ballistic missiles of limited range by reverse engineering, copying or modifying missiles obtained from other states.

Effects on Control and Verification

The processes that can result from technological maturation have two broad effects on control and verification: a loss of leverage, and a loss or a degradation of information.

Supply control strategies are based on either or both the scarcity of the thing supplied or the ability to organize suppliers to act in concert. Both of these come under strain as a result of technological diffusion and technological maturation. The growing weakness in supply control means that denial strategies become less effective, and that efforts to promote internationalized production chains, rather than national production chains, come under strain. As well, the ability of suppliers to require conditions in return for access to their scarce goods is also eroded, and this means that the link between supply on the one hand and non-proliferation obligations and verification of these obligations on the other is weakened. Beyond this, useful materials, equipment or information may actually be readily obtained, through reverse engineering of items already on hand in a state or through information networks or supplies available for other uses. The Iraqis, for example, apparently drew on US Centres for Disease Control and on medical supply houses for some of their organism samples in their biological weapons programme.

As for information, the multiplication of foreign suppliers on both the national and the sub-national levels means that more actors must be monitored and coordinated, which creates additional problems for the creation and administration of concerted supply control efforts. In addition, the ability of purchasers to unpackage technology, and to acquire it either at home or at further removes from the targeted chain of production complicates the supply control effort. What can you do when, in the words of David Kay, “a Macintosh 140 Powerbook ... has more computer power than was available to U.S. scientists doing weapons’ design work in 1967....”⁴ A state may become less dependent on foreign supply, or may be able to draw significantly on items, or channels of procurement (especially for information) difficult or impossible to control. This opens up great possibilities for clandestine procurement activities, and complicates the problem of knowing just what a state is in fact doing.

The control and verification problems are further complicated not only by the existence of dual-use, or even general-use, technology, but also by the ability and the willingness of a state to make do with processes and equipment that may be second-best or even obsolete. We cannot afford to overlook these

4. David Kay, “Iraqi Inspections: Lessons Learned”, *Eye on Supply*, 8 1993, 89.

technologies, or the possibility that other technological developments may make them more attractive or accessible.

If we try to keep track of everything, however, whether in a verification system or an export control list, we may find our information gets so fragmented and so ambiguous, and at such removes from the weapons production chain, that its usefulness is considerably diminished. We may so clog our systems that we raise, rather than lower, the noise-to-signal ratio and thus lose whatever warnings our systems can pick up.

Some other potential effects on verification systems can be seen. McFate *et al* have suggested a number of potential 'synergies' among various sources of or techniques for gathering information for verification purposes.⁵ These can form a dense and highly-interactive network of mutually-reinforcing connections. In practice, however, not only might these synergies be limited in effect but also the interactions could be negative as well as positive:

1. Specific verification agreements may draw explicitly on only some of the possible sources or techniques, and even within those used, only on a subset. Thus, the possibilities for mutual reinforcement or compensation will be limited.
2. If a verification agreement uses a principle that the information sought will be the 'minimum necessary' to perform the verification function, there will be further limitations on the interactive effects.
3. Because of the interactive effects, weaknesses in one source or technique could weaken the operation of others. If one source of information can trigger a check by another, a weakness in the triggering source generates a weakness in the checking source. Loss of information from foreign suppliers, for example, increases reliance on information voluntarily provided by a state subject to verification, and entails the loss of an independent check. Other verification techniques that could be triggered by such independent information are correspondingly weakened.

Thus, in any actual verification system considered in terms of this potential network, the prospects for compensation for losses in one source by drawing on another are reduced, and the possibility of damage in one source weakening the rest of the system is enhanced.

Some Lines of Response

There are a number of possible response strategies to deal with these effects. Supply control may be a wasting asset, but it is not yet completely exhausted.

5. Patricia B. McFate, Sidney N. Graybeal, George Lindsey and D. Marc Kilgour, *Constraining Proliferation: The Contribution of Verification Synergies*, Arms Control Verification Studies No. 5, (Ottawa: External Affairs and International Trade Canada, March 1993).

Remaining leverage can be used to extend non-proliferation obligations and attendant verification systems. One possibility is putting verification requirements on equipment exports, on the principle that if something is important enough to be controlled, it is important enough to be verified. Requiring full-scope safeguards, or at least using a contagion principle, rather than simply item-specific requirements, could also be a line of response.

Dealing with the information problem in both control and verification is important, and a number of possibilities exist here. The first, and the natural, response is to seek more information. One possibility would be to extend verification systems to cover key equipment. Other possibilities could be to encourage greater transparency and greater supply of information as a confidence-building measure. It may be necessary to reconsider what types and degree of information are minimally necessary for verification purposes. All of these could extend export control lists and verification requirements, however. The obvious danger of this has already been noted: the overburdening of a system with fragmented data of dubious worth. While more information may be desirable, it must be carefully focused, and this may entail some pruning of lists. Some possibilities will be omitted in this process, but for them we may be able to lean on back-up monitoring by national intelligence systems.

An alternative response is to make better use of information already available. This requires stronger coordination and better information-sharing among agencies within the same government, as well as between governments. The Nuclear Suppliers Group Warsaw meeting produced an agreement to share information on export requests that were refused, but sharing on granted requests was left to voluntary action.⁶ Some form of clearing-house or register could be a possibility here, whether or not within an international verification organization.

A particularly important area of response, above all where clandestine weapons production efforts are concerned, is in the use of National Technical Means (NTM) and National Intelligence Means (NIM).⁷ These provide an essential back-stop to control and verification systems, but it must be possible to use them effectively in interaction with other techniques. Both of these have their problems. Both can be misled: Iraq used its knowledge of the patterns that photo-interpreters would look for to disguise some of its nuclear activities, while Argentina reportedly encouraged Western intelligence to seek out a non-existent plutonium production reactor, to divert it from its uranium

6. International Atomic Energy Agency, INFCIRC/254/Rev. 1/Part 2, (July 1992), *Communications Received from Certain Member States Regarding Guidelines for the Export of Nuclear Material, Equipment and Technology*.

7. Following the usage in McFate *et al*, NTM refers to such means as satellite reconnaissance and other remote sensing systems, while NIM covers other information-gathering methods, especially the use of 'human intelligence'.

enrichment activities.⁸ Burck and Flowerree's discussion of the public evidence concerning Libya's suspected chemical weapons production plant at Rabta demonstrates the difficulties of drawing conclusions from both NTM and NIM.⁹

Nonetheless, both NTM and NIM may serve useful check functions on other information, and useful trigger functions. In regard to this latter use, it is particularly important that verification systems have provision to bring information from these sources into play, even where they are not formally part of the normal verification mechanisms. Such information should be able to trigger a consultative process, or even a challenge inspection process. The Chemical Weapons Convention presents such a possibility, and the International Atomic Energy Agency's Non-Proliferation Treaty safeguards system is moving in this direction within the confines of its 'special inspection' powers. The Parties to the BTWC added the possible use of a consultative mechanism to the treaty's repertoire of mechanisms in 1986. It is absolutely crucial that verification systems not be restricted simply to checking on the use of declared items, but also include whether or not declarations of items and activities are complete: this was a point obvious in Soviet-American discussions decades ago, yet it seems to have evaded practical implementation in multilateral efforts until recently. As part of this, of course, it is not merely enough to verify specific materials or items on a list. Since production methods or equipment may be adaptable, since the second-best, the obsolete, or the unusual may also be used, verification exercises of a challenge sort must be directed at the fundamental obligations, not simply at whether or not specific listed items are properly reported or used.

Latent Proliferation and Mature Technology Proliferation

A final area I want to touch on concerns two different proliferation styles and the responses to them. What I have been examining could be subsumed under the general heading of 'latent proliferation' – the spread of general capacities which give weapons potential. This, however, oversimplifies the situation.

Latent nuclear proliferation, particularly as it developed as a concern in the 1970s, was based on a fear that states, by acquiring significant civilian nuclear facilities, could thereby develop a latent capacity to make nuclear weapons, and to do so at a lower cost on the margin. Thus, interest in plutonium breeding and in reprocessing were seen as undermining the nuclear non-proliferation regime. A similar argument could have been made even more strongly in the biological and chemical areas, in particular. Responses to this

8. Kay, "Iraqi Inspections", 91. David Albright, "A Proliferation Primer", *Bulletin of the Atomic Scientists*, 49 (5) 1993, 18.

9. Gordon M. Burck and Charles C. Flowerree, *International Handbook on Chemical Weapons Proliferation*, (New York: Greenwood Press, 1991), 281-298.

perceived problem in the nuclear area included trying to hinder exports of 'sensitive' facilities, to require safeguards on exports, and to encourage internationalization of certain services.

The problem of latent capabilities is real, and such responses could still be valid and useful, although the spread and maturation of technology could undermine their viability. A mitigating factor in this erosion is that states with basically a civilian interest, or a civilian interest with a relatively limited interest in a weapons option on the side, might still be interested in acquiring fairly advanced – thus fairly demanding and scarce – technology. This could require a considerable amount of necessarily overt foreign cooperation. Thus, for example, although Brazil did have a nuclear weapons programme, it also had civilian nuclear ambitions – both for domestic nuclear power and for nuclear exports – and an interest in submarine propulsion. This may have influenced the Brazilian interest in developing enrichment technology, which is more demanding than a simple, plutonium-based weapons production route. We should note that the Brazilian-West German nuclear co-operation agreement of 1975 was preceded by, and was accompanied and followed by, various technical co-operation agreements which were intended to transfer skills and technology to Brazil. The German assistance was to be under safeguards, although in fact some leakage seems to have occurred from the civilian to the military programme.

Because their civilian requirements may lead them to desire up-to-date technology and they could be susceptible to economic considerations, states that are basically only latent proliferators may be susceptible to control strategies of denial, conditional access or internationalization. If acquisition of technology by such states is either permitted or unstoppable, at least they might be subjected to verification requirements that might increase the transparency of their activities, including raising the chances of discovering clandestine activities, or at least check or hinder leakage into any clandestine activity. If a strong interest does not exist in a real weapons option, much less if a weaponization decision has not been made, a control strategy of conditional access, and 'normal' verification, could be enough. If a weapons option is not strongly pursued, it could be susceptible to political forces. Control and verification methods may be sufficient to deal with the technological problem while persuasion and confidence-building are brought to bear.

In contrast, there are those states which I would call 'mature technology proliferators'. North Korea, Iraq, and post-revolution Iran are possible examples. Rather than having a strong civilian interest, with a weapons option on the side, these states may have little or no civilian interest, or even little or no civilian capability. What they may have is a strong, immediate and direct interest in the weapons, not just in a weapons option. Whether or not they have some base civilian capability, the weaponization decision has effectively been

made, and they are out to acquire whatever they need to give effect to that decision. For these states, a sophisticated weapon, or a sophisticated or economical production process, may be unnecessary or even, if it gets in the way, undesired, at least immediately. It may be nice to have the best weapon, but a weapon that will do the job will do. Thus, mature technology proliferators may not seek the latest, best, technology. They may want, instead, whatever produces a useful weapon, in the quantity and time desired and at acceptable cost. Older or second-best technologies, which may be in themselves more accessible, may do perfectly well.

Mature technology proliferators do not present the same opportunities for leverage for non-proliferation efforts as latent proliferators. As well, because they may be better able to acquire their needs piecemeal and assemble the requisites through clandestine efforts, they may present somewhat different, and very difficult, control and verification challenges. For latent proliferators, verification of declared facilities and capabilities, and some efforts to discourage some open acquisitions, may provide a suitable basis for policy. An ability to detect clandestine activity is, of course, still desirable, but more stress can be placed elsewhere in the set of non-proliferation efforts. For mature technology proliferators, the importance of supply control for denial is increased even though its adequacy is challenged. This puts greater stress on improved information management to assist in denial strategies. Verification systems with challenge inspection possibilities are also of crucial importance. Where possible proliferators are not already within a regime with non-proliferation and verification obligations, conditional-access supply strategies, with full-scope or at least contagion requirements, could be used to get some purchase on them.

Conclusion

The spread of basic technological capabilities with a weapons potential cannot be stopped. The maturation of such technology, and of specific weapons technologies, are merely part of a broader process. As this spread develops, however, control and verification strategies can be used to try to generate increased transparency in a state's foreign acquisitions and domestic activities, to uncover clandestine activities, and to hinder or at least provide some degree of warning of weaponization. It may be very difficult, however, to deal with a state willing to use crude or even obsolete but still serviceable methods to produce a weapon which is equally crude but serviceable, given its circumstances and needs. To deal with such a state, there must be a strengthening of control at the front and verification at the back end of production: at the front through improved methods to render transparent, and if necessary to block, acquisition activities, and at the back through challenge verification mechanisms applicable to these states.