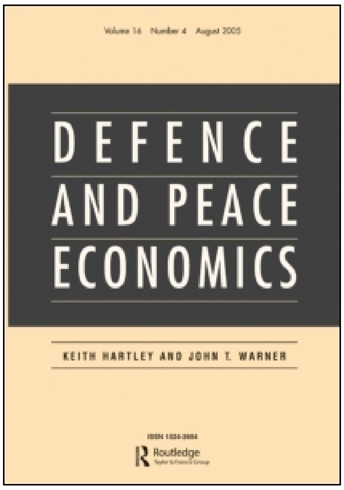

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MULTI-CHANNEL SUPPLY CHAIN FOR ILLICIT SMALL ARMS

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To generate effective policy to reduce the proliferation of illicit small arms in developing countries, governments must understand how the weapons are distributed and illegal stockpiles formed. This paper describes the structural characteristics of small arms supply chains and models mechanisms delivering the weapons to illicit users. The paper draws on the experience of countries in Southeast Asia and the Pacific Melanesian states. By pointing to the structural complexity of small arms supply chains, it highlights challenges that multiple channels of supply pose for governments seeking to curb the flow of small arms into illicit stocks.

Keywords: Small arms; Supply chain; Weapons stockpiles; Illicit arms; Black markets; SALW

JEL Codes: L140, L640, O170

INTRODUCTION

Each year, 50,000–100,000 people are killed directly by small arms and light weapons (SALW) in 'low-level' conflicts, particularly in poor countries. At least twice as many die indirectly as 'collateral' victims of conflict driven by SALW.[1] In this paper, we seek to throw light on the key mechanisms of proliferation and diffusion by which these deaths occur and the challenges of arresting or disrupting their operation. We focus on small arms, as they are by far the largest component of SALW, and on groups that hold and use such weapons illicitly.

Explanations of the proliferation, or diffusion, of small arms use necessarily involve analyzing stock-flow relationships. Acquired through legitimate government purchases, legal stocks of highly durable small arms are, in principle and practice, a ready source of flows into illicit

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[1] These 'real weapons of mass destruction' (SAS, 2001:1) include revolvers and self-loading pistols, rifles and carbines, assault-rifles, sub-machine guns and light machine guns; heavy machine guns, grenade launchers, portable anti-tank and anti-aircraft guns, recoilless rifles, portable launchers of anti-tank and anti-aircraft missiles, and mortars of less than 100 mm caliber (UN Panel of Governmental Experts on Small Arms, 1997, cited in SAS, 2006: 9). The UN's definition is policy-oriented and was developed to build a practical framework to address the challenges posed by widespread use of SALW in conflicts in developing countries.

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hands. In this paper, we leave aside discussion of legal government acquisition processes and focus on how small arms reach the hands of holders of illicit stocks.

Data on the size and value of small arms stocks and flows are of mixed quality and variable coverage internationally. The global stock of modern military firearms is estimated at about 200 million weapons, about two thirds of them concentrated in only ten countries (SAS, 2006).[2] But only 8% of these (about 16.3 million) have been publicly declared by their governments. Law enforcement agencies hold an estimated 26 million weapons. Production to build and replenish these stocks is thought to take place in about 1200 companies in 90 countries and to generate about eight million new legal firearms every year (Stohl *et al*., 2007: 12).[3] Accurate production data are almost entirely unavailable for major suppliers in Russia and China. The documented value of legal SALW exports, about $US2 billion in 2003, is perhaps only half of the actual legal total (SAS, 2006: 66–67). Official statistics frequently betray inconsistencies between national small arms import and export data.[4]

We identify as ‘illicit’ the weapons held, accumulated and used by non-state armed actors and refer to their owners and users as ‘illicit arms holders’ to emphasize that such people do not normally buy arms directly from legitimate sources of supply. The proliferation of illicit small arms has significant potential implications for mortality rates and injury in any community, although it cannot always be assumed that non-state actors are more likely to misuse weapons than those employed by national governments. However, illicit arms are of particular interest precisely because, by definition, they lie outside the control of governments. The illicit holding of small arms, especially by insurgents, poses a potential threat to the state monopoly of lethal force, possibly undermining social and economic stability and introducing an element of contestability into the rule of law. Second, illicit small arms may be used by criminals to establish and maintain control of illegal economic activities.

We highlight here the complexity of small arms supply chains and the challenges such complexity poses for agencies seeking to disrupt or impede the flow of weapons to illicit arms holders. As we show, illicit supply chains are usually extensions of legal channels. Legal channels involve transfers between weapons manufacturers, government and military purchasers, licensed brokers, wholesalers and retailers, and members of the public legally entitled to own arms. Illicit weapons, by contrast, are often stolen from government stocks, traded illegally or captured in battle. Flows of illegal arms tend to be mediated by black markets or to be the subject of non-market transfers.[5] Information on illicit transfers is even more fragmented and incomplete than that for small arms generally (SAS, 2005), but Stohl *et al*. (2007: 12) suggest that annual global sales of illicit small arms total $US1 billion, about a quarter of the annual value of the legal trade.

[2] The global total includes 141 million automatic rifles, 27 million pistols and revolvers, 12 million machine guns and 20 million of other firearms (SAS, 2006: 37). It excludes older weapons that remain in military arsenals and ‘civilian-use’ firearms (60% of the total stock of firearms).

[3] Year-to-year production of military small arms fluctuates substantially as countries tend to follow long cycles of modernization and renewal for their state-owned stocks. The average period between major small arms modernization programs appears to be about 20 years (SAS, 2006: ch. 1).

[4] The most detailed information on international trade in small arms is assembled by the Norwegian Initiative on Small Arms Transfers (NISAT). Their database reveals that while some countries record low or zero small arms exports, other countries’ official records show significant imports from those nations. On the other hand, countries can sometimes claim small arms imports of a value well below that indicated in records of the nations that exported to them. NISAT also maintains an extensive archive on black market trade in small arms.

[5] It is possible to distinguish between *white* (legal), *black* (illicit) and *grey* (semi-legal) markets for small arms. White markets operate subject to active or passive government involvement and in accordance with national and international laws. Black market transactions occur without official government approval and in violation of national and international laws. Grey markets involve governments or their agents exploiting legal loopholes or circumventing national and/or international laws to arrange arms transfers (e.g. covert arms sales to insurgents or embargoed governments) (Stohl *et al*., 2007: 13, following SAS, 2002). The line between white and grey markets is often blurred.

In this paper, we offer a stylized analysis of the mechanisms for 'funneling' small arms to illicit users. Common examples of how small arms are transferred from legal to illegal stocks include:

- the illegal activities of government officers who, for example, take bribes to issue export licenses;
- the looting of government arsenals and stockpiles, as in Albania in 1997 when half a million weapons were stolen;
- the theft and loss of weapons from insecure and poorly managed government stockpiles (e.g. the estimated 8500 weapons annually stolen or lost from South African police and military keeping);
- armed service personnel selling their weapons, as over 3000 Russian soldiers did in 1993;
- leakages from legal civilian holdings (e.g. South African owners lost nearly 16,000 small arms to theft in 2004–2005, weapons later sold on the black market); and
- unlicensed craft production of guns for the black market (Stohl *et al*., 2003: 13–15).

With the exception of the massive looting of government stockpiles during national crises (e.g. Albania in 1997 or Taliban's 'assisted' capture of 18,000 AK-47s from an arms dump in Pasha, 1994), most leakages from legal to illegal stocks are small: hundreds or thousands per annum relative to stocks that total hundreds of thousands or millions.

We draw on the experience of countries in Southeast Asia and the Melanesian states of the Pacific (i.e. 'Asia-Pacific') as a case study to illustrate what is a global phenomenon. The region offers a highly varied cross-section of economic conditions and socio-economic structures. It includes the 'Tiger' economies of Singapore and, increasingly, Malaysia; developing countries such as the Philippines and Viet Nam; the unstable economies of Papua New Guinea and Solomon Islands in the western Pacific; and Burma (Myanmar), long governed by a military junta and internationally ostracized. In 2007, the region was marked by few armed conflicts and accounted for only a small fraction of small-arms related casualties, direct and indirect, throughout the world.[6] A history of past conflicts has, however, left the region with a stock of legacy weapons including Second World War rifles and small arms familiar from the Vietnam War.[7] There is a flourishing legal and black market trade in the region (Alpers, 2005; Alpers and Twyford, 2003; Buchanan and Atwood, 2002; Capie, 2002, 2003; Davis, 2003a, 2003b; Phongpaichit *et al*., 1998). These accounts have prompted us to develop the multi-channel supply chain framework presented below with a view to showing the complexity of small arms supply chains and the challenge they present to disrupting supply and stifling proliferation.

[6] In 2007, there were no inter-state conflicts in south-east Asia. On the other hand, ethnic armies were operating along the Thai-Burmese border while the region's most serious communist insurgents, the New People's Army, were at work in the Philippines, as were factionalized Islamist groups in the south of the country (Davis, 2003a, 2003b). The activities of a long-running secessionist movement in Aceh, Indonesia reached a negotiated end in 2005. An Islamist insurgency has burst into occasional violence in Thailand's south since 2004. In the western Pacific, armed conflict had erupted in Bougainville (Papua New Guinea), Fiji and Solomon Islands at various times in the 1990s and since 2000. Small arms used in these episodes were either 'leaked' from official stockpiles or made by the combatants themselves (Alpers and Twyford, 2004; Alpers, 2005).

[7] During the 1970s and 1980s, the USA and the Soviet Union

> sent millions of small arms and light weapons to their allies in the region … for example,… the CIA purchased hundreds of thousands of AK-47s from China, Poland, Egypt and Turkey, which it passed on to the *Mujahedeen*…. and the influx of arms via Pakistan … overwhelmed Pakistan's ability to regulate the flow of arms through its territory. During the decade-long conflict, an estimated 400,000 US-supplied AK-47s and millions of other weapons entered Pakistan. Although these guns were intended for the *Mujahedeen*, many were diverted to criminals in Pakistan, revolutionaries in Iran and other actors in unknown destinations. In addition, millions of weapons remained in Pakistan and Afghanistan after the Soviet withdrawal. (Stohl *et al*., 2007: 26)

Small arms diffusion into illicit hands in the Asia-Pacific region mostly involves recycling older weapons left in the region as a legacy of past conflicts.[8] There are not, at present, large injections of new weapons from outside the region and 'ideologically motivated' cross-border supplies have become less significant over the years.[9] With the exception of Chinese arms reaching non-state entities in north-east Burma and India (Davis, 2003a), there is no evidence of current large-scale transfers to armed insurgents for financial or political gain (Buchanan and Atwood, 2002). There are also indications that cross-border traffic in small arms in Southeast Asia has been in decline recently (Phongpaichit *et al*., 1998: 153).

The main features of the illicit small arms market in Southeast Asia are cross-border smuggling, 'leakages' from state security stocks and the capture and fabrication of weapons within conflict zones. In the Pacific, smuggling and similar 'leakages' also occur but battle captures are minimal and weapons fabrication (usually craft production) is not as sophisticated as in Southeast Asia. For insurgents and criminal elements throughout the region, the main source of small arms old and new appears to be leakages from state stockpiles. Leakages arise from weak or corrupt stockpile management or the deliberate siphoning-off of weapons for personal or political gain and weapons are also captured from government hands through raids on armories, convoys, checkpoints and outposts. Ammunition and grenades are sold by soldiers on the front line or, in larger shipments, by officers and officials as business deals (Buchanan and Atwood, 2002: 21).

The relative simplicity of small arms technology and the longevity of many conflicts have encouraged craft production in the region.[10] In the Pacific, weapons are crafted to look like military small arms but limited attention is paid to potential performance under warfighting conditions (Alpers, 2005). Gunsmithing techniques are more advanced in Southeast Asia where craft producers, many of them arms-holders themselves, display a capability for making and re-fabricating small arms, ammunition and rocket-propelled grenades (Buchanan and Atwood, 2002: 21).

Illicit holders and users of small arms fall into a number of classes but distinctions can sometimes be blurred. State and non-state actors appear clearly separable, for example, but the former may nonetheless find ways of transferring small arms to 'friendly movements' in a country if they see it as politically expedient to do so.[11] And weapons may also be redirected to paramilitary entities – adjunct groups to national security forces occupying an ambivalent position in relation to state control.[12] Insurgents, politically motivated, and criminal groups can also be distinguished in terms of their objectives. But insurgents sometimes

[8] For example, two million Soviet arms and over 270 million rounds of ammunition were supplied between 1964 and 1971 to North Vietnam (Capie, 2002). According to Ezell (1988), the departing US forces left behind in Vietnam over 150,000 tons of ammunition and over 2 million small arms including handguns, assorted rifles including M16A1s, M60s and grenade launchers. American small arms transfers to Laos and Cambodia 1950–1975 totaled over 500,000 items (Capie, 2002). Vietnam War-era weapons have subsequently been re-exported as far as Cuba and Latin America and, closer to source, to the New People's Army (the armed wing of the Communist Party of The Philippines) in The Philippines. Ex-Vietnam small arms have also been included in drug shipments to Hong Kong and sent back to collectors and dealers in the USA (Capie, 2002).

[9] In south-east Asia, Cambodia and Thailand are key arms suppliers, with many legacy weapons from the Vietnam and Cambodian conflicts originating in or transiting through these states. In recent history, China has been a major supplier of small arms to protégé groups in the region. For example, the Khmer Rouge in Cambodia received weapons from this source until well into the 1990s (Phongpaichit *et al*., 1998).

[10] Small arms production draws on mature technology accessible to illicit gunsmiths once weapons prices rise by enough to finance the purchase of high-quality materials and repay the time and effort required to machine components.

[11] It was advantageous for Thailand, for example, to have a bulwark of armed non-state actors along its border with Burma over several decades, keeping both the Burmese and communists as far from Thailand as possible (Phongpaichit *et al*., 1998: 129; Smith, 1999: 277).

[12] At the time of East Timor's independence vote in 1999, the presence of Indonesian-backed militias provided a well-known example of paramilitarization (e.g. Greenlees and Garran, 2002).

cross-subsidize their primary activity (the 'armed struggle') by engaging in secondary criminal activities including kidnapping and extortion, protection rackets, drug trading and robbery.[13]

Initiatives to restrict the proliferation of small arms have been prominent in recent years (IANSA, 2005). A global catalyst was the UN 2001 *Programme for Action to Prevent, Combat and Eradicate the Illicit Trade in SALW*. The *UN Firearms Protocol* signed in 2001 came into force in 2005 as the first 'binding' global agreement on small arms. To develop effective policy to contain SALW, however, it is necessary to have a good understanding of how illicit small arms are distributed and illicit stocks formed. But the mechanics of SALW supply chains are not well understood. Our main research question is this: given what is known of the nature of the relevant supply chains, is it possible to devise policy that is able, effectively, to disrupt the transfer of small arms to illicit holders and users? The aim of this paper is to show the structural complexity of illicit small arms supply chains and demonstrate the scale and intensity of the challenges faced by governments and international agencies if they seek to curb the diffusion of weapons into illicit hands. We also argue that small arms proliferation is often a symptom of other, deeper problems, which have to be addressed if small arms-related violence is to be contained.

The paper is structured as follows. The next section provides a stylized description of multi-channel supply chains feeding stocks of illicit small arms. The third section discusses the challenges that multi-channel supply chains pose for governments seeking to curb the flow of small arms into illicit stocks; and the final section comments on the scope for action by those who wish to reduce the proliferation of small arms.

Throughout the paper, references to Asia-Pacific and illustrative examples are normally contained in footnotes.

MULTI-CHANNEL SUPPLY CHAIN

The Mechanics of Small Arms Supply

In this section, we present a stylized model of the illicit arms supply chain, illustrating its applicability to the Asia-Pacific region by reference to footnotes.[14] Figure 1 shows the stylized supply chain structure in a country where most military-style small arms are initially purchased by the government for the armed forces, police and other government agencies licensed to carry weapons (the national security sector). This may also include paramilitary organizations that are armed by the military to operate as militias or vigilantes and engage in activities that the government (or the military) does not wish to be associated with directly. The total stock of arms held by the security sector is represented by a box labeled *government stock*, GS. The latter comprises weapons and ammunition and various other elements of small arms such as gun-sights and maintenance equipment. In Figure 1, we also show the flow of arms from GS to paramilitary organizations. For simplicity we ignore 'leakages' from the paramilitary stock to illicit arms holders. This is because these leakages are conceptually similar to those shown in the figure. Similarly, we do not show in Figure 1 the stock of

[13] As an example, the United Wa State Army (UWSA), Burma, was once part of the Burma Communist Party but, since its ceasefire with the country's junta, it has become an illicit narcotics exporter and trafficker of small arms into Laos, Cambodia and north-east India (Davis, 2003a). It is now also an ally of the Burmese military government. However, this is not to say all non-state entities are inherently criminally-inclined. Some insurgent groups see themselves as legitimate entities (e.g. 'governments-in-waiting'), provide social services and collect taxes in regions under their direct control.

[14] For a similar approach see Boutwell and Klare (1998: 17).

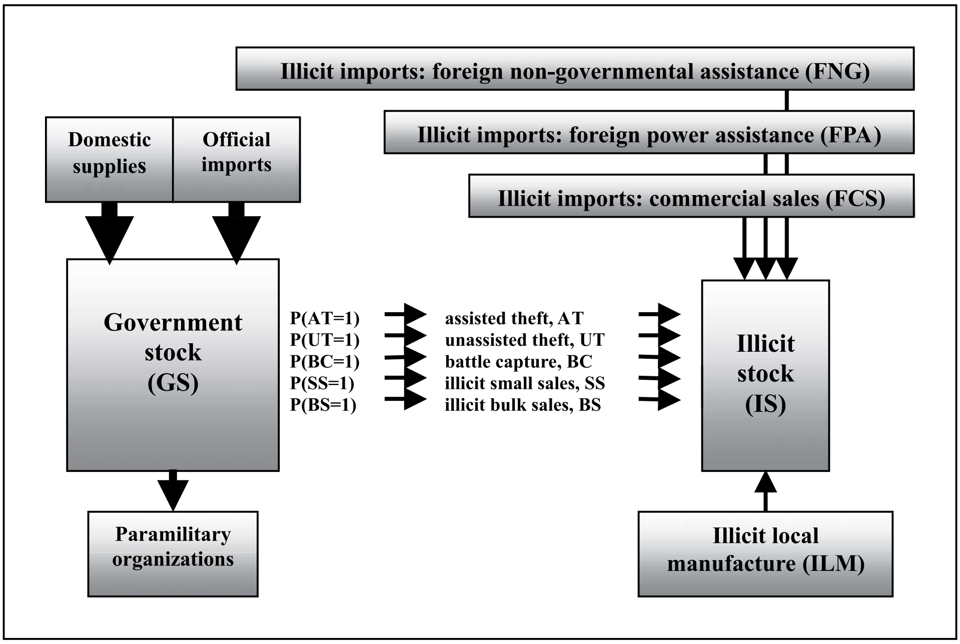

FIGURE 1 Sources of illicit supplies

firearms held legally by civilians and outflows from that stock to illegal destinations. Our aim here is to outline the basic mechanics of multi-channel supply chains feeding stocks of illicit small arms and to highlight the challenges of illicit arms control. Adding further elaborations would increase the realism of the model but only reinforce our key message that it is impossible, in practical terms, to 'seal' legal stocks of firearms to stop all leakages to illicit destinations.

The rate at which new firearms are added to the government stock depends on factors such the size of the national security sector, the government's ability to pay for new small arms, complementary investments in related activities (e.g. training of recruits, availability of ammunition), and the rate at which the existing stock becomes obsolete.[15] In Figure 1, the stock of arms is formed through two inflows: *official imports* (i.e. purchases from foreign arms suppliers and/or purchases and donations from overseas governments) and *domestic supplies* sourced from in-country manufacturers. Some countries rely entirely on imports; others may insist on arms acquisitions having high local content, using local designs or obtaining technology and production licenses from abroad to make small arms locally.[16]

Figure 1 shows no depletions from the stock due to the aging or obsolescence of weapons.[17] In part, this is because small arms are durable and in many countries there is a tendency to

[15] This is either as a result of global technological change in small arms, which induces many small arms users to upgrade their weapons even through there is no specific adversary to confront, or because of the nature of weaponry used by the latent or actual adversaries (an 'arms race' between potential or actual adversaries).

[16] There is no small arms production in the Melanesian Pacific at present. Small arms are made under license in Southeast Asia (e.g. a M16 derivative in Singapore; China manufactures its own copy of the AK47, known as the Type 56 or M22).

[17] However, 'official' depletions of the stock can easily be incorporated in our stylized model. For example, the government may decide to export old weapons by selling them directly to another country. Alternatively, the government may decide to donate surplus weapons to a friendly government or supply them illicitly to support 'friendly elements' in an 'unfriendly' country. These outflows have been omitted from the stylized supply chain as they complicate matters without adding much to the substance of our argument.

retain old weapons in stock 'just in case'. Often, older weapons can be used to arm paramilitary and other 'client' groups, at home or abroad, so there is a 'filtering process' in which the older vintages of the stock are progressively diverted to lower priority users within the government sector (transfers of weapons within the 'government box' in Figure 1).[18] Thus, the stock may grow over time even though a proportion of it is mothballed as 'old stocks' or kept in a state of disrepair as a source of spare parts. The vintage structure of the stock makes it easier to 'leak' weapons out that are regarded as obsolete. It is these illicit 'leakages' from the government stock into the hands of people whom the government has no desire to arm that are of interest to us in this paper.

As noted, the *illicit stock of arms*, IS, arises either because there are *leakages from GS*; or because of *illicit imports* (see below); or in-country manufacture shown in Figure 1 as *illicit local manufacture*, ILM. Arms manufactured illicitly in-country are often, but not always, of inferior quality (relative to factory-made weapons). While their craft producers are often highly skilled, they may only have access to poor quality materials.[19] Nevertheless, craft-industry weapons may compete on price and availability with other sources of illicit supply.[20]

In some countries, the most important source is leakages from the government stock. Five such 'leakage' channels are shown in Figure 1:

- *assisted theft*, AT, occurs when weapons are made available to insurgents or criminals, by people working within the government sector, for family, tribal, ethnic, religious or ideological reasons. Sometimes, AT takes the form of arrangements to gain favor with the 'other side', such as providing intelligence about military and police storage facilities or details of arms shipments. While this form of theft does not require a reciprocal payment, resources are required to raid government armories and intercept arms convoys and most of these activities are risky up to a point;
- *unassisted theft*, UT, occurs when insurgents or criminals rely on their own resources to arrange the robbery of armories or the interception of arms shipments.[21] Normally, we would expect these activities to be more risky and resource-intensive than assisted theft;
- *battle capture*, BC, involves the capture of arms in combat, shown in Figure 1 to be unidirectional[22] with arms flowing from the government to illicit stocks;[23]

[18] For example, Australia loaned the fledgling East Timor Defence Force a batch of old military assault rifles to train with until it obtained its own stocks.

[19] For example, gunsmiths in the Philippines are known for their craftsmanship and, thus, are able to produce and/or modify more sophisticated weapons (Capie, 2002: 73; and Anon, 2005). In Papua New Guinea, on the other hand, primitive weapons have been made from water pipes by less skilled craftsmen (Alpers, 2005: 45). Alpers also notes the significance of craft-production elsewhere in the Pacific. Craft-produced small arms comprised almost three quarters of those handed over in the Solomon Islands in 2000–2001 (Alpers and Twyford, 2003: 25).

[20] For example, in PNG in 2005, a home-made primitive shotgun sold, on average, for about US$52 in black markets of Southern Highlands Province (SHP) but for US$102 in National Capital District (NCD), both areas notorious for a high incidence of armed violence. However, a more sophisticated (bolt-action) home-made shotgun designed to use the cheapest and most common 5.56 × 45 mm ammunition, sold for around US$324 in SHP. A factory-made (simple) shotgun averaged US$344 in SHP and US$695 in NCD and a factory-made pump-action shotgun sold for US$1433 in SHP and US$2110 in NCD. By comparison, a black market M16/AR15 averaged US$2655 in SHP and US$2760 in NCD (SAS, 2006: Table 7.4: 177).

[21] For example, in 2000, the Malaitan Eagle Force raided the state armories of the Solomon Islands (Alpers and Twyford, 2003: 39).

[22] Clearly, arms are also captured from insurgents by the government forces. This is not shown in the figure but could easily be incorporated as an extension of the stylized description.

[23] For example, in Burma, insurgents used the advance of the Burma Army as an opportunity to obtain new weaponry cost-effectively by ambushing the advancing army units (Smith, 1999: 307).

- *illicit small sales*, SS, take place when soldiers or policemen sell ammunition or stolen weapons to supplement their often-meager pay.[24] These 'retail' activities are often opportunistic, *ad hoc* and small scale (in their totality though, they may be quite significant); and
- *illicit bulk sales*, BS, are likely to involve corrupt government officials and the military stealing and re-selling larger quantities of weapons.[25] Alternatively, they may sell intelligence or 'leave the gates open' to insurgents or criminals.

Illicit imports may involve donations by friendly powers or non-governmental 'benefactors' and are shown in Figure 1 as *illicit imports: foreign power assistance*, FPA, and *illicit imports: foreign non-government assistance*, FNG, respectively.[26] In 2007, these are not the major sources of weapon inflows into the Asia-Pacific region. While these shipments from abroad may be free of charge, the recipient may have to collect them from a particular drop-off point, which may be difficult and risky to arrange. As, by definition, all these imports are clandestine, the last leg of the delivery process may also necessitate the recipient's direct involvement. This may stretch the recipient's resource base and impose significant transaction costs.[27] Commercial imports arranged through international (black market) arms dealers, shown in Figure 1 as *commercial sales*, FCS, may also require a complementary in-kind effort from the recipient to obtain them, and must be paid for at prices set in the arms black market. In some cases, the commercial arrangements take the form of counter-trade with firearms paid for by reverse shipments of narcotics or similar barter arrangements.[28]

Likelihoods of Arms Transfers

What are the odds that a weapon held in the government stock or a gun made by an illicit gunsmith ends up in the stock of illicit small arms? Suppose that there is enough detailed information to quantify likelihoods of successful inflows into the illicit stock as probabilities.[29]

First, we consider 'leakages' from the government stock of weapons, GS. Each of the five channels (AT, UT, BC, SS and BS) is designated a value 0 or 1 depending, respectively, on whether the channel is active or inactive. The probability that a weapon held in GS will reach illicit hands through a given channel is then denoted P(AT), P(UT), etc. In the case of AT, for example, when AT=0 the channel AT is inactive and P(AT=0) = 0. If AT=1, then P(AT=1) = ψ, where ψ is the probability that a weapon is stolen and successfully transferred

[24] A former combatant in the East Timorese independence movement, Falintil, reveals how occupying Indonesian forces would sell small amounts of arms and ammunition to members of Falintil (Pinto and Jardine, 1997: 102).

[25] Engaging in both 'retail' and 'wholesale' activities, the Indonesian armed forces were shipping weapons 'still in crates' to the separatist movement in the northwestern region of Aceh, orchestrated, according to Kingsbury, by 'corrupt generals' for whom it was just 'a business deal' (Kingsbury, 2003: 209).

[26] In Southeast Asia, for example, arms were transferred to Cambodian factions during the reign of the Khmer Rouge (Capie, 2002: 28, 97–98, 100–101). Many of these weapons have been re-transferred across the region and beyond. In terms of non-government involvement in arms transfers, both the United Wa State Army and the Patani United Liberation Army have been accused of involvement in arms transfers to other armed movements (Anon, 2000; and Capie, 2002: 41).

[27] The precariousness of external sources is noted by a member of the Moro Islamic Liberation Front of the Philippines, stating that external arms sources were both '"expensive and risky" not to mention the process being "long"' (Davis, 2003b: 33).

[28] For example, remnants of the Khmer Rouge were supplied with arms from Thailand bartered for gem and logging concessions in the late 1990s and the Mong Tai Army, headed by the 'Opium King' Khun Sa, were said to have bartered narcotics for SA-7 missiles from Cambodia (Phongpaichit *et al.*, 1998: 145–148; Davis, 2003c: 17).

[29] Such information might be obtained from press reports (e.g. NISAR archive) but is unlikely to be complete or highly accurate. However, as noted in the Introduction, quantities leaked from legal military and law enforcement stocks tend to be small: hundreds to thousands rather than tens of thousands. It is only when large military powers supply their 'friends' or client groups that large quantities of firearms are involved (see footnotes 7 and 8).

to the illicit stock via channel AT. Thus, if experience indicates that 500 firearms are stolen by government employees each year from a GS of 500,000, there is a one-in-a-thousand chance (0.001) that a government-owned weapon will enter the AT channel. To calculate ψ, however, we must allow for events that may prevent a weapon from reaching illicit hands through the channel – interception by government forces, for example. If only half of the weapons that enter the AT channel actually reach IS, $\psi = 0.0005$. The expected annual quantity of weapons supplied through that channel, q_{AT}, is then:

$$q_{\mathrm{AT}} = \mathrm{P}(\mathrm{AT} = 1)\ \mathrm{GS} = \psi\,\mathrm{GS}$$

In our example, if GS were 600,000 and P(AT=1) = 0.0005, ceteris paribus, each year, 300 weapons would be expected to end up in IS.

Similar reasoning applies to each one of the five leakage channels from GS shown in Figure 1: the quantity of weapons expected to be 'leaked' successfully from GS through channel j is:

$$q_j = \mathrm{P}(j = 1)\ \mathrm{GS}, \text{where } j = \mathrm{AT},\ \mathrm{UT},\ \mathrm{BC},\ \mathrm{SS},\ \mathrm{BS}$$

and, for all five channels, the total quantity of weapons expected to be leaked from GS to IS is:

$$Q = \sum_{j=\mathrm{AT}}^{j=\mathrm{BS}} q_i = \sum_{j=\mathrm{AT}}^{j=\mathrm{BS}} \mathrm{P}(j = 1)\mathrm{GS}$$

In reality, each supply channel may involve several activities to initiate and complete a 'leakage' of arms from GS to IS. For example, suppose that the AT channel comprises three activities: arms theft, AT_1, arms transfer, AT_2, and arms collection at destination, AT_3. Then the probability that a weapon is stolen from the government stock, GS, by a government employee is $\mathrm{P}(\mathrm{AT}_1{=}1)$, and $\mathrm{P}(\mathrm{AT}_2{=}1)$ and $\mathrm{P}(\mathrm{AT}_3{=}1)$ are, respectively, the probabilities that the 'mule', AT_2, delivers the load successfully to a collection point, and the arms recipient, AT_3, collects it successfully for the end user. ($\mathrm{P}(\mathrm{AT}_2{=}1)$ is a conditional probability in that AT_2 can only be undertaken if AT_1 is successfully accomplished, and so on.) For the AT channel to operate successfully, all three tasks must be accomplished so that the probability that the AT channel delivers a weapon to IS is the product of probabilities of all constituent tasks being accomplished successfully:

$$\mathrm{P}(\mathrm{AT} = 1) = \mathrm{P}(\mathrm{AT}_1 = 1) \times \mathrm{P}(\mathrm{AT}_2 = 1) \times \mathrm{P}(\mathrm{AT}_3 = 1)$$

and P(AT=0) = 0 if at least one of its constituent tasks cannot be accomplished.

The probabilities of various tasks in a sequence being accomplished may or may not be statistically independent of each other. For example, the propensity to assist-through-theft, $\mathrm{P}(\mathrm{AT}_1{=}1)$, may be constant: determined by the number and position of those in government service who are willing to steal to assist the illicit arms holders. Or, it may be a function of incentives (e.g. bribes) or effort that the recipients of illicit arms are prepared to make to pressure ('lobby') government employees to steal arms for them, in which case $\mathrm{P}(\mathrm{AT}_1{=}1)$ and $\mathrm{P}(\mathrm{AT}_3{=}1)$ may have a common underlying cause (the amount of 'money' or 'effort' devoted by the end recipient to keep channel AT active and effective). Under rational maximizing assumptions, the cost of additional 'lobbying' at the margin required to increase

$P(AT_1=1)$ should be more than offset by the expected value of a weapon obtained as a result of it.[30]

In addition to leakages from GS, there are inflows through other channels such as imports, FNG, FPA and FCS, and illicit local manufacture, ILM. The probabilities associated with the illicit arms imports, FNG, FPA and FCS, and the illicit in-country production of weapons, ILM, require somewhat different interpretation than the leakages from GS. Accordingly, P(FNG=1) is the probability that a weapon designated by a foreign non-governmental source for an illicit arms holder will be transferred successfully to the illicit stock, IS, in the destination country. Thus, if FNGS is the total size of the shipment from that source to the IS in the country under consideration, the expected annual addition to the stock is:

$$q_{\mathrm{FNG}} = \mathrm{P(FNG} = 1)\mathrm{FNGS}$$

Similar reasoning applies to FPA and FCS, where, respectively, P(FPA=1) and P(FCS=1) are the probabilities that a weapon is successfully delivered to IS in the destination country and FPAS and FCSS are total shipments designated for that destination. P(ILM=1) is the probability that a weapon made by illicit (craft) domestic gunsmiths, whose total annual production is ILMP arms, finds its way to the illicit stock, IS. Thus:

$$q_{\mathrm{ILM}} = \mathrm{P(ILM} = 1)\mathrm{ILMP}$$

Given the nature of illicit production, we would expect most illicit domestic output to be destined for IS. However, there may also be illicit exports of domestic black market craft products and the craft-gunsmiths themselves.[31]

The market price is likely to influence the propensity of government officials to steal arms for resale as well as the probabilities of commercial imports and in-country illicit production. Ceteris paribus, we expect these probabilities to be directly related to the local black market price of illicit weapons (i.e. as black market prices increase, it is more tempting to steal weapons for resale, import them or make them locally). In addition, as prices increase, there is an incentive for a craft-gunsmith to make more weapons for the local market and, possibly, to enhance the quality of the product. Thus, successful government action to reduce the supply of firearms (say, through buybacks) is likely to increase the black market price and, in time, induce more (and perhaps better) weapons to be supplied. As prices change, the relative importance of different supply channels changes as illicit arms holders favor channels that offer ‘best value for money’.[32] For example, if weapons leaked from GS are of the same

[30] For an insurgent, for example, the price of a weapon is a measure of the cost of capital (a tool of ‘trade’). If a black market price of the ubiquitous AK-47 assault rifle is US$400, there is no point in spending more than this amount to secure an equivalent weapon through the assisted theft channel. Similarly, the government may try to deter its employees from stealing weapons, say by imposing a death penalty for arms stealing. This may reduce $P(AT_1 = 1)$. Alternatively, the government may invest resources to reduce the probabilities of successful completion of other tasks, $P(AT_2 = 1)$ and $P(AT_3 = 1)$, say by increasing the number of paid informers within the government sector. Again, from the government perspective, the marginal benefit of reducing the flow of weapons into IS, should offset the marginal cost of reducing $P(AT_2 = 1)$ and $P(AT_3 = 1)$ (more informers).

[31] For example, craft products and craft-producers have both been ‘exported’ from the Philippines to Japan, where the weapons are both ‘untraceable and can be used on a fire-and-forget basis’ (Davis, 2003b: 36).

[32] The full cost of acquisition is likely to include both an in-kind component (the channel-specific effort needed to arrange and complete the delivery) and, where appropriate, a monetary component, i.e. the purchase price of commercially supplied or stolen-for-profit weapons. For illicit arms holders in more prosperous countries, the in-kind component may be more significant than the purchase price, while in underdeveloped island economies in the Pacific a potential insurgent might be prepared to go a long way to acquire the weapons but be short of cash to pay for them.

quality but less costly than imports, sourcing leaked weapons should, ceteris paribus, be preferred to importing them. In practice, weapons are heterogeneous, perceived quality varies and the supply chain is likely to be diversified as shown in Figure 1 with some, perhaps the bulk, of supplies being leaked from GS.

In Figure 1, nine paths are shown to be potentially available to channel illicit arms to IS. If all these channels were active and given GS, FNGS, FPAS, FCSS and ILMP, the expected annual addition to the illicit stock of weapons, ΔIS, would be:

$$\Delta \mathrm{IS} = \sum_{j=\mathrm{AT}}^{j=\mathrm{BS}} \mathrm{P}(j=1)\,\mathrm{GS} + \mathrm{P}(\mathrm{FNG}=1)\,\mathrm{FNGS} + \mathrm{P}(\mathrm{FPA}=1)\,\mathrm{FPAS} + \mathrm{P}(\mathrm{FCS}=1)\,\mathrm{FCSS} + \mathrm{P}(\mathrm{ILM}=1)\,\mathrm{ILMP}$$

The actual number of weapons added to the illicit stock depends not only on what could potentially be supplied, say ΔIS_s, but also what is actually demanded, say ΔIS_d. Market forces should ensure that $\Delta IS_s = \Delta IS_d$. If $\Delta IS_s > \Delta IS_d$, we would expect the black market price of illicit weapons to decline. This would reduce the quantity supplied and increase the quantity demanded until $\Delta IS_s = \Delta IS_d$.

Such adjustments may take many forms, including changes in probabilities and quantities designated for the illicit stock. For example, with lower prices, there would be less temptation to steal weapons for re-sale and fewer weapons would be designated for commercial imports (FCSS would decline).[33] Conversely, if $\Delta IS_s < \Delta IS_d$ prices would normally increase, deter buyers at the margin and increase the quantity supplied. Given the potential diversity of supply channels, we would expect black markets to be quite competitive, with active competition for and in the market. The supply-demand adjustments will continue until $\Delta IS_s = \Delta IS_d$.

There is a further aspect of supply that needs to be addressed: a multi-channel supply chain is active only if there is at least one successful *path* between the source of arms and their illicit destination. For a path to be successful, every constituent part located along that path must be operating successfully. Further, each path will have a given capacity (i.e. be *capacitated*) and thus will only be able to handle a certain (maximum) ‘load’ of firearms. If the total requirement at the illicit destination exceeds the capacity of a particular path, other paths will have to be used to meet the total requirement. Normally, there may be several potential paths with the combined loads exceeding the end requirement, in which case, it may be sufficient that only x out of y channels (a quorum) are active and successful and the remaining $(y - x)$ channels remain dormant. To meet a growing requirement in its entirety, the number of active channels, x, will increase to approach the total number of possible paths, y. When $x = y$, all channels have to be activated to meet the requirement.

In an earlier example, we noted that the probability of the assisted theft channel (AT) working successfully, P(AT=1), is a product (a series) of probabilities of its constituent elements (activities). Similar reasoning applies to all other supply channels in Figure 1. If it is sufficient for only one of the nine channels ($x = 1$ and $y = 9$) to be active to meet the end user’s demand, the probability that the multi-channel (parallel) supply chain, MCSC, delivers a weapon to IS, P(MCSC=1), is:

$$\mathrm{P}(\mathrm{MCSC}=1) = 1 - [1-\mathrm{P}(\mathrm{AT}=1)]\,[1-\mathrm{P}(\mathrm{UT}=1)]\,[1-\mathrm{P}(\mathrm{BC}=1)]\,[1-\mathrm{P}(\mathrm{SS}=1)]\,[1-\mathrm{P}(\mathrm{BS}=1)]\,[1-\mathrm{P}(\mathrm{FNG}=1)]\,[1-\mathrm{P}(\mathrm{FPA}=1)]\,[1-\mathrm{P}(\mathrm{FCS}=1)]\,[1-\mathrm{P}(\mathrm{ILM}=1)]$$

[33] However, lower prices may (perversely) induce the authorities to be less vigilant; thus, increasing the probability that a ‘leaked’ weapon gets through to the illicit destination.

(see the next section for formal explanation of parallel arrangements).

The latter is the best case scenario (maximum channel redundancy) for the illicit arms holder as the probability that the PSC satisfies the illicit demand for weapons is greater than the probability of a single delivery channel meeting the same requirement. For example, in Figure 1, providing that each channel has the capacity to meet the demand and eight channels can be kept in a standby mode while one channel is active, there are also eight 'spare' channels, which are presently dormant but can potentially be activated if the working channel is disrupted or taken out of commission. Conversely, this is also the worse case scenario for an agency that wishes to disable the MCSC as all nine channels must be disabled for the supply chain as a whole to be disabled.

In sum, as quantities supplied and demanded vary, adjustments occur in the form of active channels closing and dormant channels opening until the required quantity is provided. The activation and closure of channels is likely to be costly, so the most cost-effective channels are likely to be used first and others only as demand increases. In general, the availability of different supply channels increases the efficiency of those that are currently active. We would expect the multi-channel supply chain to be at its most competitive and cost-effective if only x out of y channels were active, the costs of channel switching were low and $y–x$ was a large number of potential alternative supply paths. It follows that policing such 'flexible' supply chains is difficult and costly.

Despite its apparent simplicity, Figure 1 embodies and implies a great diversity and complexity of supply arrangements. In reality, there are very many players who are either active or could be potentially be involved in the supply of illicit small arms. The following section focuses on the robustness of the multi-channel supply chain. In addition, we consider how flows of arms could be disturbed or impeded through external intervention.

THE ROBUSTNESS AND VULNERABILITY OF THE MULTI-CHANNEL SUPPLY CHAIN

Parallel and Series Supply Arrangements

To generalize, we represent the MCSC as a system of stocks and flows with small arms moving along routes (channels or paths). A system can be described as an entity comprising elements (constituent parts) with paths (lines of communication or activity) between them. For example, these 'constituent parts' can be individuals or organizations that are involved in small arms transfers. A system is usually shown as having an input (e.g. a weapon embarking on a path to an illicit destination) and an output (a weapon reaching its illicit destination) and a path through the system connecting the input to the output (Wolstenholme, 1999). We use the system representation to assess the extent to which flows of small arms along these transfer paths can be disrupted by governments seeking to reduce small arms proliferation.

To operate effectively, the supply chain should be a coherent system of its constituent parts. That is, each constituent part of the chain should be relevant (i.e. the supply chain should not include activities which, whether completed successfully or not, have no impact on the flow of arms through the chain). Neither should a coherent chain include elements that, when changing status from 'inactive' to 'active', reduce the flow of arms (produce negative outputs).[34]

[34] Clearly, some elements may have negative productivity when they put other people at risk or fail badly in their tasks. But a coherent supply chain should not contain such dysfunctional elements.

Two basic system structures are of particular interest: the series and parallel systems. A series system (a series arrangement of constituent parts) works only if all constituent parts work, and a parallel system (a parallel arrangement of constituent parts) works if at least one of its elements works. For example, in the series system, there are two arms dealers, A and B, and both have to be active and successful for a weapon to be delivered to the illicit user. In the parallel case, it is sufficient that at least one of these dealers 'works' for a firearm to reach its end destination (for definitions see the Technical Appendix).

Tie and Cut Sets

To understand more clearly the potential for successful policy intervention in illicit arms movements, it is helpful to consider an alternative approach to representing supply chain arrangements. This involves structuring them as 'tie' (path or link) and 'cut' sets. A tie set of elements is a set joining the system input to its output, while the cut set contains elements which, if removed from the system, would make it inactive. The tie, or link, is active if all elements on the path are active, and a cut set corresponds to an inactive system. Of particular interest to us are the minimal tie and minimal cut sets. The minimal tie set is the smallest number of elements needed to connect the input successfully to the output. The minimal cut set is the smallest number of elements which, if removed from the system, would cause it to become inactive. 'These sets can be used to express any coherent system as a parallel arrangement of series subsystems or the series arrangement of parallel subsystems (Leemis, 1995: 23). This way of representing the supply chain is important for illuminating the degree of robustness of any multi-channel supply chain through which small arms flow to their illicit destination, and what needs to be done to cut the supply links (supply ties) to disable the whole chain. While arms recipients will seek to keep the chain active (tie arms sources to their illicit destination), governments will seek to prevent potential recipients from obtaining arms, and therefore would be interested in disabling (cutting) the chain. How this might be achieved is discussed below.

From the perspective of illicit arms holders, the best arrangement to secure the required quantity of weapons is a highly diversified supply chain consisting of *z* parallel delivery channels (paths) of which only *y* need to be active. To illustrate, we re-draw Figure 1 as a system of nine parallel supply channels (paths) tying the sources of small arms to their final destination, IS. This is shown in Figure 2, where each channel (path) is shown as a series of three elements that must stay active for the channel to deliver the end product. For simplicity, assume that all activities along a path are statistically independent of each other.

In the general case, if there are *n* elements, *i* in each series channel, $i = 1, 2, \ldots, n$, and *j* channels set up in parallel, where $j = 1, 2, \ldots, z$, the probability of channel *j* being able to deliver a weapon to IS is:

$$\mathrm{P}\,(X_j = 1) = \Pi\ \mathrm{P}(x_{ji} = 1), \text{ for } i = 1, 2, \ldots, n; \text{ and } j = 1, 2, \ldots, z$$

The probability that the pure multi-channel supply chain comprising *z* channels delivers a weapon to IS is thus:

$$\mathrm{P}\,(X = 1) = 1 - \Pi\ [1 - \mathrm{P}(X_j = 1)], \text{ for } i = 1, 2, \ldots, n; \text{ and } j = 1, 2, \ldots, z$$

When illicit demand exceeds the capacity of a single channel, the successful operation of the supply chain (from the illicit arms holder's perspective) requires that *y* out of *z* channels are

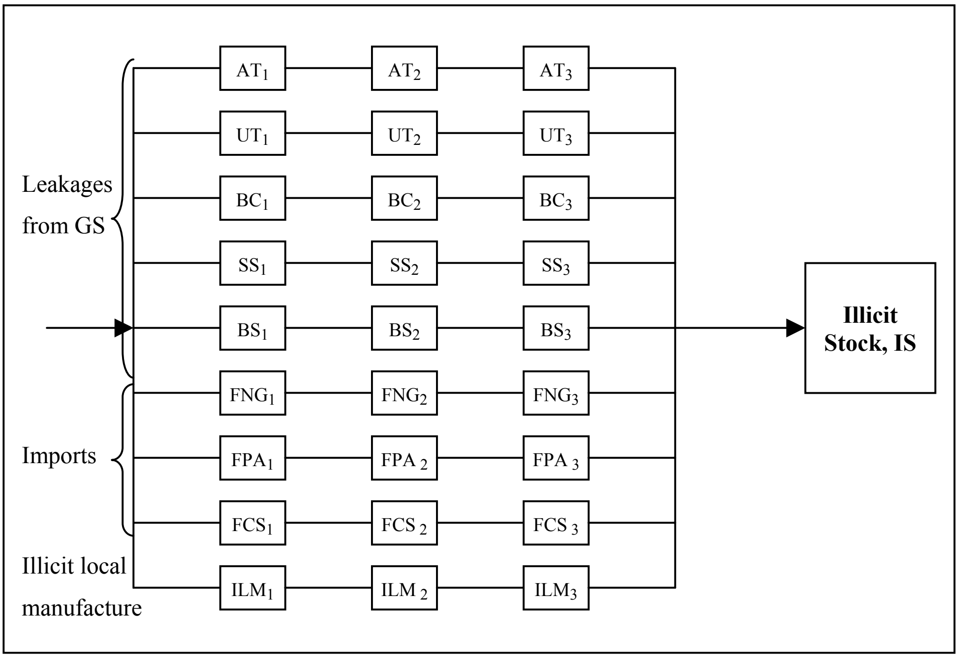

FIGURE 2 The multi-channel arms supply chain: parallel supply ties

active and successful for the end demand to be met.[35] (The stylized representation of this case is too complicated to be shown here.) However, although the y-out-of-z system is not as robust as the ‘pure’ 1-out-of-z arrangement shown in Figure 2, the y-out-of-z multi-channel supply chain is still more dependable than a chain consisting of only one supply channel. The probability that y out of z channels in the multi-channel supply chain are active to jointly deliver the required end product is:

$$\mathrm{P}\left(X\big|_{y/z}=1\right)=\frac{z!}{y!(z-y)!}\mathrm{P}^{y}(1-\mathrm{P})^{z-y}$$

Generally, the dependability of the y-out-of-z arrangement, $\mathrm{P}(X|_{y/z}=1)$, increases as y decreases to 1 and/or z grows very large. The benefit of increased channel redundancy (in a parallel structure) increases with the number of channels, z, and the ‘purity’ of the parallel arrangement (y decreasing to 1). That is, the supply chain is more likely to deliver the end product when there are many alternative supply channels currently dormant but potentially available to be activated, at low cost, although only a few of them need to be used at any one time. However, although the overall dependability of the multi-channel supply chain increases as the number of channels (minimal tie sets), z, increases, there are diminishing returns to adding further parallel paths. That is, $\mathrm{P}(X|_{y/z}=1)$ increases with z, albeit at a decreasing rate (Wolstenholme, 1999: 111–112).

From the perspective of illicit stockholders, the increased dependability of the multi-channel supply chain comes at a cost, both in terms of resources and potential penalties. This

[35] In our example of a nine-channel supply chain, it may be necessary for, say, two out of nine channels to work to deliver the required load.

is because the complexity of the multi-channel arrangements increases as the number of channels, *z*, gets larger. To form each additional channel *j*, even if it remains inactive, requires channel-specific investments and involves additional risks. Switching channels may also be costly, even if the inactive channels, $z - y$, remain in a stand-by mode. The benefit to illicit stockholders of increased supply chain dependability, will be greater the more inelastic is their demand for weapons. The marginal benefit of increased supply chain dependability must then be compared with the cost of additional supply chain complexity.[36] From the illicit arms holder's perspective, the optimal supply chain structure is achieved when the marginal benefit of increased dependability equals the marginal cost of increased complexity:

$$\delta B[P(X|_{y/z}=1)]/\delta z = \delta C[P(X|_{y/z}=1)]/\delta z$$

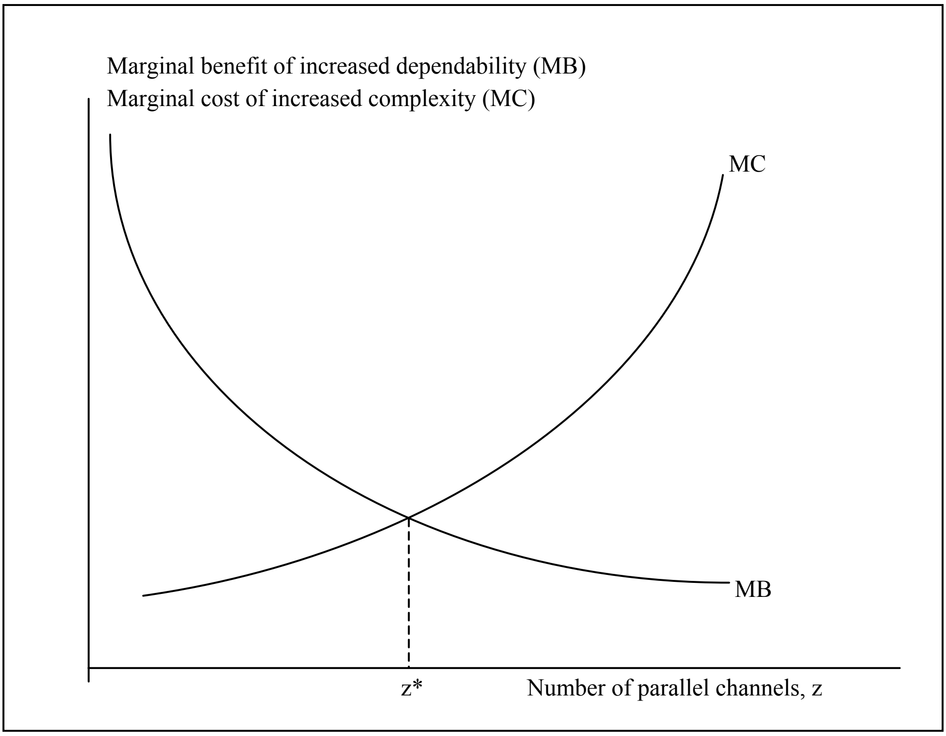

FIGURE 3 Optimal structure of the multi-channel supply chain: illicit arms holder's perspective

[36] The marginal benefit for some small arms may be quite high (e.g. a high precision rifle to be used in a high profile assassination). However, we expect demand to be reasonably price elastic as alternative technologies can be substituted for firearms when their prices are high (e.g. IEDs). Thus, cross-elasticities of demand for different types of weapons should also be considered. Killicoat (2007) collected black market price data for the family of AK-47 assault rifles, the most ubiquitous small arm, of which 70–100 million have been produced since 1947 (SAS, 2004: 28). Interestingly, throughout the 1990s and 2000s, the average price recorded for the AK-47-family weapon was significantly lower in countries experiencing civil war/insurgency than in others. For example, in 2005, the average black market price of these weapons was US$348 in the 'civil-war' sample of countries and US$655 in the 'no-civil-war' sample (SAS, 2004: Table 2). (However, as no data are available on quantities traded in different national black markets, price elasticities of demand cannot be estimated.) In the mid-2000s, AK-47 style weapons sold legally in US white markets commanded prices of between US$115 and US$525, depending on type, the country of manufacture (a proxy for quality) and weapon configuration (Fjestad, 2007: 116).

This is shown in Figure 3, where the optimal structure of the multi-channel supply chain is z^* (i.e. the number of parallel small arms delivery channels that balances, at the margin, the investment required to form and sustain multiple supply channels with the benefit of increased dependability of the complex supply chain).

In general, the multi-channel supply chain (or ‘portfolio’ of alternative delivery paths) provides a more dependable source of supply than a single delivery chain. For the illicit arms holder, the ‘poor case’ scenario is that of the pure (single channel) series system, and the worst case scenario is the z-out-of-z parallel arrangement. In the latter case, the cost of multi-channel complexity has to be incurred, but there is no offsetting benefit of channel redundancy: to meet the demand it is strictly necessary for all potentially available channels to be active. This would be the case when illicit market demand is highly inelastic and the quantity demanded is relatively large, so it has to be distributed between several parallel channels.

Disabling the Supply Chain

The single channel arrangement (the pure series supply chain) offers the greatest potential for a government seeking to disable the flow of small arm to illicit holders. In this case, it is sufficient to remove any one of the elements comprising the supply chain to break the tie between the input and the output and, thus, disable the flow of illicit small arms.

To disable a relatively ‘pure’ multi-channel supply chain, the government would have to identify at least one cut set and find a means of removing all elements of the set. To reduce the cost of intervention, the government should identify a minimal cut set that it wished to disable so that the entire multi-channel supply chain could be disabled cost effectively. For example, in Figure 2, it would be sufficient for the government to remove only one element from every parallel channel to disable the whole multi-path supply chain (e.g. a set comprising the first element of each parallel channel, x_{j1}, for $j = 1, 2, \ldots, z$).

In reality, when z is large, there are very many minimal cut sets while governments have limited resources to disable them. To be ‘cost effective’, the government may concentrate on a ‘weak link’ in every channel, $*x_{ji}$ (for $i = 1, 2, \ldots, n$; and $j = 1, 2, \ldots, z$) where $*x_{ji}$ is, say, the ‘least costly’ element to remove (i.e. $*x_{ji}$ = min cost x_{ji}. The cost of removing elements of supply channels, x_{ji}, may be measured in money terms or in terms of the physical effort required to disable a particular link (e.g. the scale of military operations or the number of government infiltrators/spies planted in insurgent and criminal organizations). However, to identify and remove all weak links, the government would need superior intelligence about the structure of the supply chain to decide on the most resource-effective course of action. In practice, the presence of informational asymmetries and the cost of securing the relevant intelligence (detection cost) would make the identification of ‘weak elements’ of each channel most unlikely.[37] As n and, in particular, z increase, while only y channels are needed to meet the demand for illicit arms, the sheer complexity of the supply chain makes it very costly to identify even a single cut set that could be effectively targeted and eliminated. This is similar to the effort required to secure intelligence in the ‘war on terrorism’ where the marginal social detection cost (including the social cost of various interrogation techniques) increases exponentially while the marginal social benefit increases rather slowly. Such

[37] For example, the assisted theft channel may comprise many people who are prepared to steal arms from the GS. They may do it for personal, political or ideological reasons. They may also engage in theft to assist illicit arms holders as a protection payment to ensure that they or their families are not targeted in armed attacks and kidnappings. As threats posed to the government by illicit arms holders are essentially asymmetric, they are often intended to coerce those involved in the machinery of government to induce their tacit support and collaboration. Many may also steal from GS for financial gain, particularly in instances where the government sector is inherently corrupt or where security sector personnel are inadequately paid.

complexity in the multi-channel supply chain and the associated information asymmetries are the essence of the challenge faced by those aiming to stop the proliferation of small arms.

The challenge becomes even greater when disabling a supply chain requires collaboration between two or more governments. For example, consider the case of illicit commercial imports of weapons. This is illustrated in Figure 4, where a supply chain originates in a country where large quantities of small arms remain from a previous conflict (e.g. Cambodia). These stocks are often dispersed among the local population, $P_1 \ldots P_9$, which sells them to local arms dealers, $LB_1 \ldots LB_3$, who in turn re-sell them to international dealers, ID_1 and ID_2. The latter arrange transport to illicit buyers in the destination country.

In this particular context there is little the government in the destination country can do to disable the upstream segment of the supply channel unless the government of the source country is prepared to co-operate. In the exporting country, the government has more options to disable the in-country segment of the supply channel. As [$P_1, \ldots, P_9$] is a minimal cut set, the government can arrange a buyout program to crowd out the local arms dealers. For example, firearm ownership could be made illegal and all existing owners, $P_1, \ldots, P_9$, ordered to surrender their weapons within a designated time period and in exchange for a set fee. To be successful though, the government would have to buy a sufficient quantity of the weapons and this would drive the black market price up. This could also produce perverse results as higher prices for old weapons may allow arms holders to sell them to the buyback agency and use the money to purchase newer weapons smuggled in to meet demand. Alternatively, the government may arrange a crackdown on local arms dealers to drive them out of business, [LB_1, LB_2, LB_3], which is another minimal cut set. There is less scope for either source or destination country governments to drive international arms dealers out of business as they are likely to be located outside the jurisdiction of both governments. Thus, it may not be possible for either government to disable the minimal cut set [ID_1, ID_2].

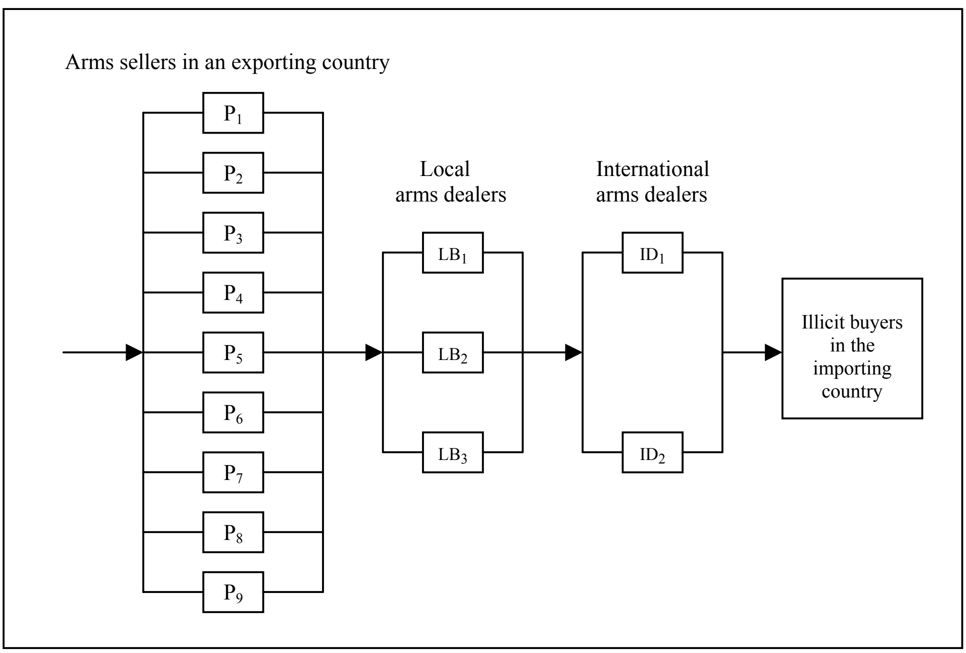

FIGURE 4 Supply chain for illicit imports

CONCLUSION

The above analysis highlights the sheer complexity of multi-channel supply chain formation. Some of that complexity may be a matter of deliberate design on the demand side of arms trafficking, when illicit arms-holders diversify sources of supply to enhance the dependability of the supply chain. Some of it though may be intrinsic to the socio-economic make-up of a country under consideration. That is, the combination of corruption, poverty, ethnic and religious tensions and political instability and previous or ongoing conflict provide many opportunities for arms delivery initiatives to originate on the supply side of the arms flow. The combination of these demand and supply factors makes it very difficult for any government to identify the minimal cut sets and take action to disable them. In this respect, illicit arms supply chains are even more difficult to deal with than supply chains for illegal drugs. While the supply chain for illegal drugs is driven almost entirely by black market forces, in the case of illicit arms flows there are additional political, ideological, financial, religious and ethnic factors that influence the direction, complexity and intensity of arms flows.

To significantly restrict the use of weapons by illicit arms holders requires, in the logic of this paper, massive resources which are not available to governments in developing countries. This is for a number of reasons:

- most of these chains are multi-channel and, as many supplies originate in-country, the cost of activating dormant supply links or setting up new channels is relatively low;
- old weapons tend to be both durable and portable, so that surges in demand can also be accommodated through shipments of old weapons from one conflict area to another. The portability of weapons makes it possible to recycle arms used in earlier conflict zones to new conflict areas;[38] and
- as small arms technology is quite mature and technological obsolescence occurs slowly, old weapons tend to retain their ‘use value’ over time. That is, small arms (as opposed to ammunition) are often more durable than their owners so that they can be recycled back into use serving more than one generation of users (e.g. the life expectancy of AK-47 is up to 50 years – Killicoat, 2007).[39]

The odds are clearly in favor of illicit arms users and suppliers who, given the scope for channel redundancy, can easily tie the sources of supplies to their illicit destination. On the other hand, to be effective, governments would have to cut/disable a large number of active and dormant channels. To achieve this would require both superior intelligence and massive resources. Superior intelligence is usually not available to enforcement agencies. As the opportunity cost of relevant resources is likely to be high in developing countries and the cost of human life is often deemed to be low, we would not expect much effort to be devoted to small arms reduction. Governments often turn a blind eye to illicit arms flows. It is only when violence associated with the proliferation of small arms poses a credible threat to economic growth or government survival that the marginal benefit of small arms reduction increases and induces the government to devote more resources to the disablement of illicit supply channels.

[38] This is particularly evident in Southeast Asia where, in the aftermath of the Vietnam War, vast quantities of weapons were left behind in countries such as Vietnam, Laos and Cambodia. Over the years, these weapons have been ‘decanted’ to other conflict zones – not just those geographically contiguous but also as far as Latin America (Capie, 2002: 100).

[39] Some makes of weapons, most conspicuously the many derivatives of the Kalashnikov assault rifle, have remained favorite weapons for generations of insurgents around the world, even though they embody the technology of the 1940s and 1950s.

When conflicts escalate, however, small arms cease to be effective and account for a declining percentage of all casualties. Light and heavier weapons replace small arms as the main capital assets deployed in battles (e.g. Sri Lanka). In asymmetric warfare, other cheap-to-use but more lethal technologies, such as improvised explosive devices (IEDs), provide far more effective means of inflicting large casualties on technologically superior forces (e.g. as presently demonstrated in Iraq and Afghanistan). Thus, a combination of different technologies and tactics can be substituted for small-arms-dominated warfare and this is likely to increase as governments succeed in disrupting supply chains for illicit small arms.

As a final observation, the proliferation of illicit small arms appears to be the symptom of deeper socio-economic malaise rather than its cause. For example, when corrupt elements in the security sector sell their weapons to insurgents or criminals, the problem to address is the pervasive corruption in the public sector. Unless the corruption is stamped out, those with access to government stocks will find a way of facilitating firearm transfers to illicit holders. In the short run, much-publicized initiatives to disable supply channels, such as arms buybacks, may have some useful demonstration effects but, given the complexity of supply chains, they are unlikely to have much impact on the illicit stocks and flows. However, as the experience of Southeast Asia shows, as the long-run economic growth accelerates and its benefits are widely shared, the incentives to supply and demand small arms change at both ends of the supply chain. While there are pockets of active insurgency, there appears less small arms-fuelled violence in Southeast Asia than a decade or two ago (see Introduction). In contrast, in the Pacific, where the slowly developing island economies are poorly integrated into the international division of labor, the arms-related violence has increased (Alpers and Twyford, 2003; Capie, 2003). In our view, a key challenge for governments serious about small-arms fuelled violence is to address the opportunity cost of holding and using illicit arms, and this is a challenge for economic policy makers rather than security agencies.

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TECHNICAL APPENDIX

A structure function, ϕ, may be used to describe whether a system is 'active' (ϕ = 1 if the system is working or 'up') or 'inactive' (ϕ = 0 when it is not working or 'down') and also defines the arrangement of elements in a system. The system structure can be represented as an arrangement of its elements, where each element is either up or down. The state of element i, x_i, can be shown as:

$$x_i = \begin{cases} 0 & \text{if element } i \text{ is down} \\ 1 & \text{if element } i \text{ is up} \qquad \text{for } i = 1, 2, \ldots, n \end{cases}$$

Element x_i may represent an individual or an organization involved in the illicit supply of small arms or an activity along a particular supply path/channel.

A structure function for a supply chain arranged as a single series channel is:

$$\phi(x) = \begin{cases} 0 & \text{if there exists an } i \text{ such that } x_i = 0 \\ 1 & \text{if } x_i = 1 \text{ for all } i = 1, 2, \ldots, n \end{cases}$$

$$= \min\,(x_1, x_2, \ldots, x_n) = \prod_{i=1}^{n} x_i$$

The series-structured supply chain is active and successful, $\phi(x)$ = 1, when all its constituent parts are active and successful, $x_1 = x_2, = \ldots = x_n = 1$, and 0 otherwise (Leemis, 1995: 16–17). A structure function for a parallel system of elements x_i is:

$$\phi(x) = \begin{cases} 0 & \text{if } x_i = 0 \text{ for all } i = 1, 2, \ldots, n \\ 1 & \text{if there exists an } i \text{ such that } x_i = 1 \end{cases}$$

$$= \max(\ (x_1, x_2, \ldots, x_n) = 1 - \prod_{i=1}^{n}(1 - x_i)$$

The parallel system is active and successful when one or more of its constituent parts are active and successful. $\phi(x) = 0$ when $x_1 = x_2, = \ldots = x_n = 0$ and 1 otherwise (*op cit.*).

For a quorum of *m*-out-of-*n* parallel elements, the structure function for the multi-element system is:

$$\phi(x) = \begin{cases} 0 & \text{if } \sum_{i=1}^{n} x_i < m \\ 1 & \text{if } \sum_{i=1}^{n} x_i \geq m \end{cases}$$

For $m = n$, the parallel system becomes a pure series system and for $m = 1$ it is a pure parallel system. The probability that a series arrangement comprising elements x_i (for $i = 1, 2, \ldots, n$) delivers the end product is:

$$\mathrm{P}(X|_n = 1) = \Pi\ \mathrm{P}(x_i = 1)$$

The probability that the pure parallel arrangement of elements x_i (for $i = 1, 2, \ldots, n$) delivers the end product is:

$$\mathrm{P}(X|_{1/n} = 1) = 1 - \Pi\ [1 - \mathrm{P}(x_i = 1)]$$

The probability that *m* out of *n* elements in the parallel arrangement operate successfully to jointly deliver the required end product is:

$$\mathrm{P}(X|_{m/n} = 1) = \frac{n!}{m!(n-m)!}\mathrm{P}^m(1 - \mathrm{P})^{n-m}$$

(Wolstenholme, 1999: 112)