Trades, Drugs, and Guns: A two-country model with endogenous growth

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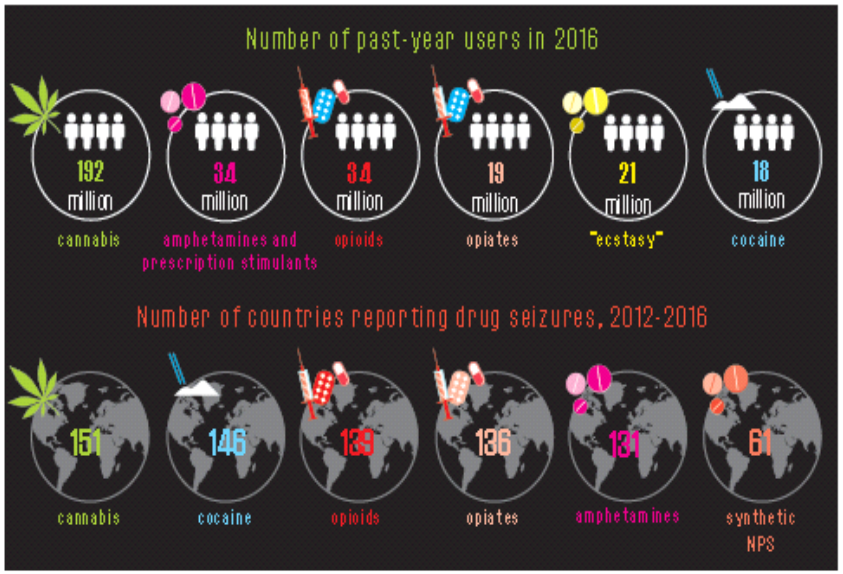
Highly Persistent Illicit Global Drug Trades



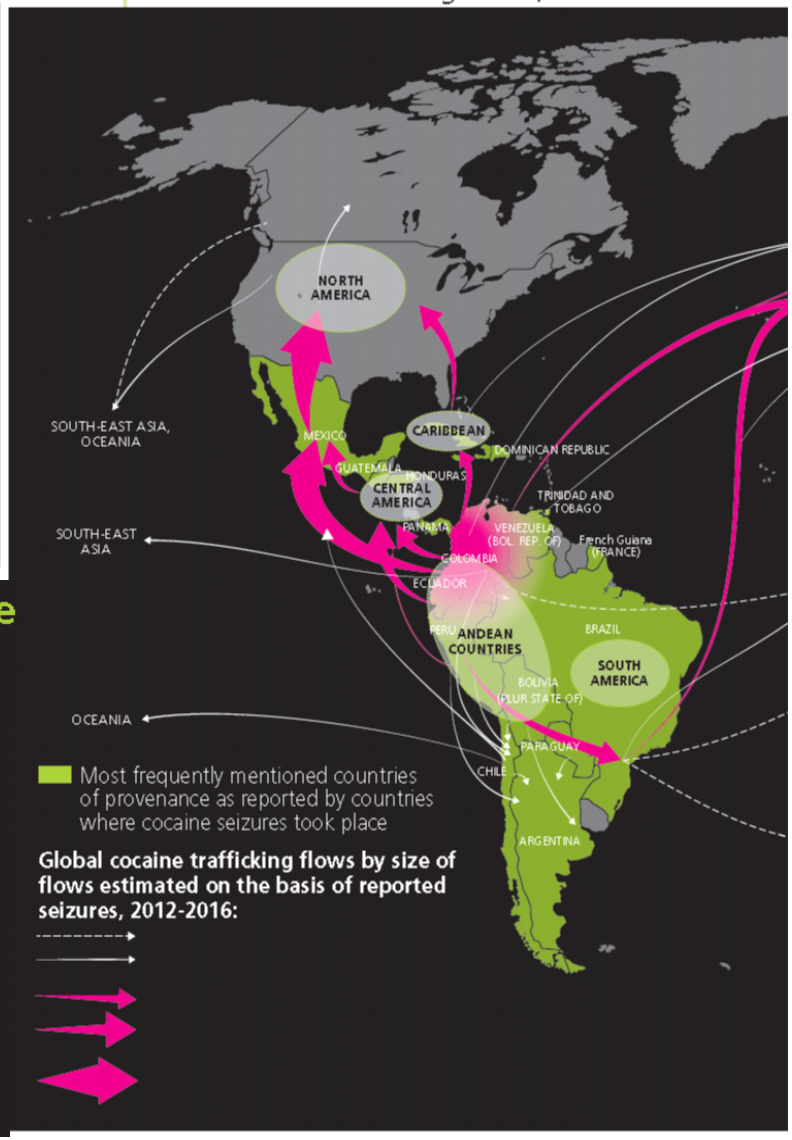
Trafficking of cannabis herb continues to be intraregional in nature

Most trafficking of cannabis herb takes place in the region where it was produced, a phenomenon that has become even more pronounced since the spread of indoor cannabis cultivation.[a] The countries most frequently reported in the period 2012–2016 as countries of origin of cannabis herb by region and subregion are as follows.

Americas

The most frequently reported source country for transnational shipments of cannabis herb in North America was Mexico, followed by Canada. Cannabis is grown in Mexico (notably in

MAP 1 | Main cocaine trafficking flows, 2012–2016

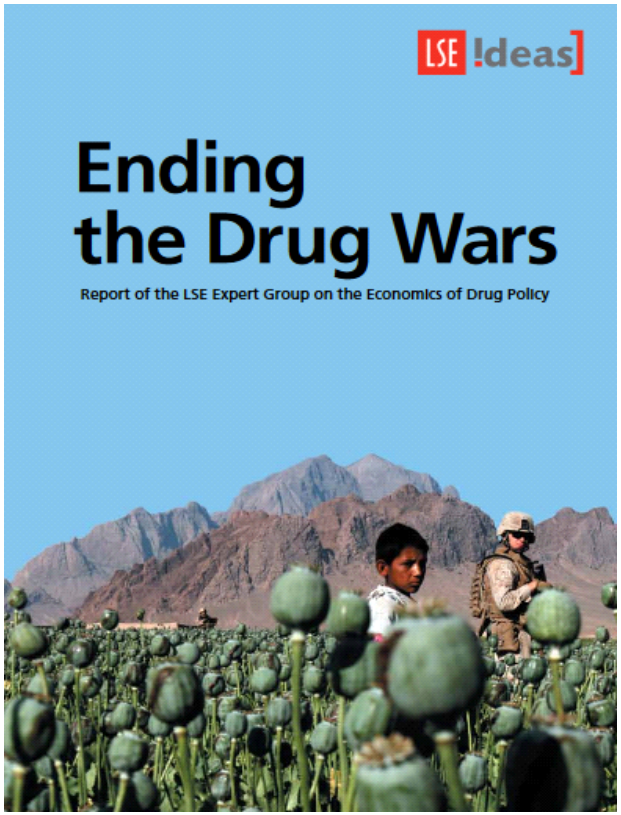


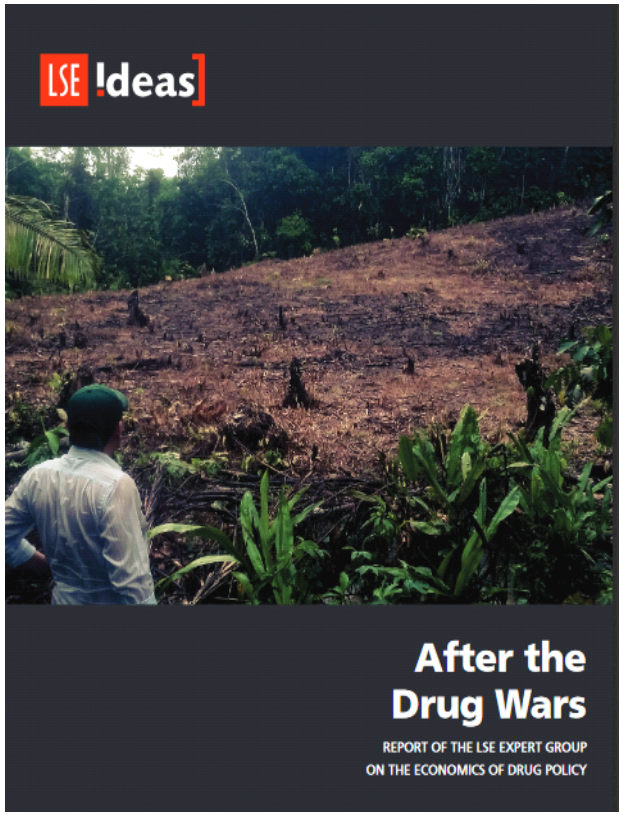
Source: UNODC, World Drug Report 2018

Time to End Restrictive Drug-Control Policies?

Did we really win the "Drug Wars"?

Perhaps, it is time to re-think and fundamentally restructure Drug-control polices to be more related to Development Agenda?





Source: *LSE* Expert Group on the Economics of Drug Policy (2014, 216)

Legalization versus Prohibition

Source: UNODC, World Drug Report 2018

TABLE 1 | Regulations for legalizing the use of cannabis within jurisdictions in the United States of America

	Alaska	California	Colorado	District of Columbia	Maine
Legal Process	Voter initiative, state statute	Voter initiative	Voter initiative, amendment to state constitution	Voter initiative	Voter initiative
Title	Ballot Measure 2	Proposition 64	Amendment 64	Initiative 71	Question 1
Date passed	November 2014	November 2016	November 2012	November 2014	November 2016
Date implemented/ required date of rule adoption	February 2015: Personal possession, consumption, cultivation October 2016: Retail sales	Not stated, but licences to be issued by 11 January 2018	December 2012: Personal possession, consumption, cultivation January 2014: Retail sales	February 2015: Personal possession, consumption, cultivation	Take effect on 7 January 2017; regulation for business to be in place August 2017
Regulatory authority	Marijuana Control Board (Alcoholic Beverage Control Board)	Bureau of Marijuana Control	Marijuana Enforcement Division (Department of Revenue)	Not applicable; considering separate legislation to regulate commercial production and sale to adults	Department of Agriculture, Conservation and Forestry
Minimum age	21	21	21	21	21
Residency requirement	None	Not specified	None	None	Not specified
Personal possession quantity	28.5 g	1 oz flower 8 g concentrate	28.5 g	57 g	2.5 oz (70.8 g) 5g concentrate
Home cultivation	Six plants, three of which can be flowering; not subject to public views; within property with lawful possession or with consent of the person in lawful possession	Six plants, away from view	Six plants, three of which can be flowering	Six plants per person; Twelve plants per household, six of which can be flowering	Six mature plants, twelve immature plants, unlimited amount of seedlings away from view and tagged with personal identification number. Property owners can prohibit home cultivation. Cultivation for medical purposes not subject to same restrictions
Interpersonal sharing	28.5 g	Yes	28.5 g	28.5 g	Yes for home grow. Not permitted for retail marijuana
Retail transaction limit	28.5 g	Not specified, presumably same limits for personal possession	Residents: 28.5 g Non-residents: 7 g	Not applicable	2.5 oz. of marijuana Twelve seedlings
Retail pricing structure	Market	Market/commercial	Market	Market	Market/commercial
Average retail price per gram after tax	Average price $20	Low quality $10 High quality $14	Medium quality $15.5	Not applicable	Medium quality $14
Maximum THC content	Not set initially	Not set initially	Not set initially	Not set initially	Not set initially
Registration requirements	None	Not specified	None	None	Not specified

Knowledge Gap to be filled ...

Large literature

- DD-side largely micro-economic or experimental studies, in tradition of Becker-Murphy (1988), Becker et al. (2006);
- SS-side on vertical-supply chain [eg: Grossman-Daniel Mejía (2008), Mejía-Restrepo (2016)].

Shortcomings:

1. Limited number of dynamic GE models that allow study of growth effects and potential policy trade-offs;
2. Separate modelling treatment of consumers'optimizing choice of drug consumption vs drugs'transhipment & production;
3. Non-adoption of a trade framework;
4. Absence of explicitly modeling of illicit firearm trades.

Our Contributions

Horizontal Perspective - Unified endogenous growth, 2-country framework with international trade and drugs control

- To preview, we found:
  1. While prohibitive drug-control policy (both DD- & SS-side) appears to be trade- & growth-enhancing to the formal sector, we uncover a *production-consumption* growth trade-off;
  2. However, there is a range of initial **rational-addiction condition** where, the more open the consuming country is, the wider the range of values that would allow drug liberalization policy to be output growth-enhancing;

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  2. However, there is a range of initial **rational-addiction condition** where, the more open the consuming country is, the wider the range of values that would allow drug liberalization policy to be output growth-enhancing;
  3. A more direct supply-side policy aimed at eradicating drug cultivation remains valid (raising formal trades & growth), though households in source country are more likely to be compensated via the resulting (formal) international-trade expansion effect, the more open it is.

Country A - Preferences

$$\max U_t = \mathbb{E}_t \sum_{s=0}^{\infty} \Lambda^s \left(\begin{array}{c} \frac{(C^A_{t+s})^{1-\varsigma_{CA}^{-1}}}{1-\varsigma_{CA}^{-1}} - \frac{\eta_L}{1+\psi} L^{1+\psi}_{t+s} \\ +\pi \frac{[\xi_{t+s}(\Xi_{t+s})^{\eta_\Xi}]^{1-\varsigma_\Xi^{-1}}}{1-\varsigma_\Xi^{-1}} \end{array} \right),$$

where π uncertain climate factor on support $(0, 1]$, subject to

$$(1-\tau_L) w_t^{T,A} A_t^{T,A} L_t^{T,A} + (1-\tau_K) r_t^{T,A} K_t = P_t^T (C_t^A + I_t) + P_t^\xi \xi_t,$$

$$\frac{\Xi_{t+1}}{\Xi_t} = (1-\phi) + \frac{\xi_t}{\Xi_t},$$

$$K_{t+1} = (1-\delta^K) K_t + I_t,$$

which yields first-order conditions, highlighted by:

$$\frac{C_t^A}{\xi_t} = \pi^{-\varsigma_{CA}} (\Xi_t)^{\frac{\varsigma_{CA}}{\varsigma_\Xi}[\eta_\Xi(1-\varsigma_\Xi)+1]} \left(\frac{\xi_t}{\Xi_t}\right)^{\frac{\varsigma_{CA}}{\varsigma_\Xi}} \left(\frac{P_t^\xi}{P_t^T}\right)^{\varsigma_{CA}}.$$

Country A - Preferences

Another 2 dynamic equations for the 2 types of "good":

$$\frac{\mathbb{E}_t C_{t+1}^A}{C_t^A} = \left\{ \frac{1}{\Lambda} \frac{\mathbb{E}_t P_{t+1}^T}{P_t^T} [(1-\tau_K)\mathbb{E}_t r_{t+1}^{T,A} + (1-\delta_K)] \right\}^{-\varsigma_{CA}},$$

$$\frac{\mathbb{E}_t \xi_{t+1}}{\xi_t} = \left\{ \begin{array}{c} \frac{1}{\Lambda} \left(\frac{\mathbb{E}_t \Xi_{t+1}}{\Xi_t} \right)^{\frac{\varsigma_\Xi}{\eta_\Xi(\varsigma_\Xi - 1)}} \frac{\mathbb{E}_t P_{t+1}^\xi}{P_t^\xi} [(1-\tau_K)\mathbb{E}_t r_{t+1}^{T,A} \\ +(1-\delta_K)] \end{array} \right\}^{-\varsigma_\Xi}.$$

The allocation of tradable consumption in second-stage follows a straightforward static optimization problem [max $C_t^A = (C_t^{A,A})^\theta (C_t^{A,B})^{1-\theta}$ s.t. $C_t = P_t^T C_t^{A,A} + P_t^T C_t^{A,B}$], yielding:

$$\frac{C_t^{A,B}}{C_t^{A,A}} = \frac{1-\theta}{\theta}.$$

Country A - Production and Government

- **Ordinary tradables:** standard perfect competition framework with continuum of identical firms $i \in (0,1)$ hiring labor & physical capital, though with 1 novel feature of:

$$\text{Productivity, } A_t^{T,A} = A_0^A \left(\frac{\xi_t}{\Xi_t}\right)^{\upsilon_A}.$$

- **Guns production:** 1 firm, producing for Government and for exports; "transform" final goods to guns: $\max_{Y_t^{T,AG}} (1-\tau_G) P_t^G Y_t^{G,A} - P_t^T Y_t^{T,AG}$, subject to $Y_t^{G,A} = A_0^G (K_t^A)^{\omega} (Y_t^{T,AG})^{\varkappa}$.

- **Government's budget**:

$$\tau_L w_t^{T,A} A_t^{T,A} L_t^{T,A} + \tau_K r_t^{T,A} K_t + \tau_G P_t^G Y_t^{G,A} + R_t = P_t^T G_t^A + P_t^G G_t^G,$$

with realizable value of the confiscated drugs, $R_t = z(1-\pi) P_t^{\xi} \xi_t$.

Country B - Preferences

$$\max V_t^j = \mathbb{E}_t \sum_{s=0}^{\infty} \Lambda^s \left[\frac{(C_{j,t+s}^B)^{1-\varsigma_{CB}^{-1}}}{1-\varsigma_{CB}^{-1}} - \frac{\eta_B}{1+\psi_B} (L_{j,t}^{T,B} + L_{j,t}^{\xi,B})^{1+\psi_B} \right],$$

subject to

$$w_t^{T,B} H_{j,t}^{T,B} L_{j,t}^{T,B} + w_t^{\xi,B} H_{j,t}^{\xi,B} L_{j,t}^{\xi,B} + \xi_j J_t^{T,B} = P_t^T (C_{j,t}^B + I_{j,t}^{T,B}),$$

$$H_{j,t+1}^{T,B} = \Theta_{HB} I_{j,t}^{T,B} + (1-\delta^{HB}) H_{j,t}^{T,B}.$$

- Similar static optimization problem for households in Country B for the allocation of ordinary tradables and labor supply:

$$\frac{C_t^{B,A}}{C_t^{B,B}} = \frac{1-\varrho}{\varrho}, \quad \text{and} \quad \frac{L_{j,t}^{\xi,B}}{L_{j,t}^{T,B}} = \frac{1-\vartheta}{\vartheta}.$$

Country B - Production

- **Ordinary tradables:** price-taking firm hiring only labor, $\max_{L_t^{T,B}} \pi_t^{T,B} = P_t^T Y_t^{T,B} - w_t^{T,B} H_t^{T,B} L_t^{T,B}$, with

  $Y_t^{T,B} = Q_t^{T,B}(H_t^{T,B} L_t^{T,B})^{\alpha}$, and $Q_t^{T,B} = Q_0^B (H_t^{T,B})^{\phi_1} \frac{Y_t^{T,A}}{K_t^A}$.

- The productivity specification means *growth* in Country B's tradable production can only be driven by growth in $H_t^{T,B}$, as it is tied to the scale of its trading partner, as seen in the first-order condition:

$$\frac{Y_t^{T,B}}{H_t^{T,B}} = Q_0^B \frac{Y_t^{T,A}}{K_t^A} (L_t^{T,B})^{\alpha}.$$

Drug production and distribution

- **Drug syndicate**'s maximization problem:

$$\max_{G_t^F, L_t^{\xi,B}} qP_t^{\xi} A_0^R (H_t^{\xi,B} L_t^{\xi,B})^{\varphi} (G_t^F)^{1-\varphi} - w_t^{\xi,B} H_t^{\xi,B} L_t^{\xi,B} - P_t^G G_t^F,$$

where q uncertain production capacity on support $(0, 1]$, yielding f.o.c.:

$$\frac{\varphi}{(1-\varphi)} = \frac{w_t^{\xi,B} H_t^{\xi,B} L_t^{\xi,B}}{P_t^G G_t^F}.$$

- **Drug distribution**: smuggling a unit of drug requires κ_t units of Country B-produced ordinary tradables traded to Country A ($C_t^{Dist} = \kappa_t C_t^{A,B}$), hence driving a wedge:

$$P_t^{\xi} = (1 + \kappa_t) P_t^T, \quad \text{where} \quad \kappa_t = \kappa_0 (\frac{\xi_t}{\Xi_t})^{-\rho}.$$

Equilibrium Conditions and Solutions

- For Country A,

$$Y_t^{T,A} = C_t^{A,A} + I_t + G_t^A + Y_t^{T,AG} + C_t^{B,A}.$$

- For Country B,

$$\begin{aligned} Y_t^{T,B} &= C_t^{B,B} + C_t^{A,B} + C_t^{Dist}, \text{ or equivalently,} \\ Y_t^{T,B} &= C_t^{B,B} + (1+\kappa_t) C_t^{A,B}. \end{aligned}$$

- For the market of guns,

$$Y_t^{G,A} = G_t^G + G_t^F.$$

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- For the market of guns,

$$Y_t^{G,A} = G_t^G + G_t^F.$$

- Finally, we define the *dynamic international trade equilibrium* and the associated *balanced growth equilibrium* to solve analytically for the dynamic system characterizing the model solutions. The system is parameterized where the BGE variables are matched to first moments of the respective annual series for US and 5 Central American economies in 1990-2015 period.

Is legalization or prohibition the better approach?

In the benchmark,

An increase in the overall "drug-acceptance" climate in Country A (π)

	Initial Values	Benchmark	$v_A = -0.072$	$v_A = 0.072$	$\varsigma_E = 0.3$	$\chi = 0.5$	$\rho = 0.5$
Growth of tradable output in Country A	0.025	**-0.0099**	-0.0105	-0.0090	-0.0488	-0.0016	-0.0016
Growth of private consumption, Country A	0.025	**0.0044**	0.0044	0.0044	0.0034	0.0044	0.0053
Growth of physical capital stock, Country A	0.025	**-0.0099**	-0.0105	-0.0090	-0.0488	-0.0016	-0.0016
Growth of tradable output in Country B	0.025	**0.0000**	0.0000	0.0000	0.0000	0.0000	0.0000
Growth of private consumption, Country B	0.025	**-0.0099**	-0.0105	-0.0090	-0.0488	-0.0016	-0.0016
Growth of relative human capital stock, Country B	0.000	**-0.0052**	-0.0052	-0.0052	-0.0079	-0.0052	-0.0062
Growth of current-period drug production	0.025	**0.0044**	0.0044	0.0044	0.0034	0.0044	0.0053
Current-to-accumulated drug consumption ratic	0.525	**0.0052**	0.0052	0.0052	0.0079	0.0052	0.0062
Price of drugs	7.500	**-0.0032**	-0.0032	-0.0032	-0.0049	-0.0032	-0.0379
Growth of total guns production	0.025	**-0.0099**	-0.0105	-0.0090	-0.0488	-0.0016	-0.0016
Price of guns	4.120	**-0.0043**	-0.0043	-0.0043	-0.0066	-0.0043	-0.0211

Drug Legalization in Consumer Market

Drug Legalisation in Consumer Market - Long-run Growth effects in Country A:
Different value of ϕ and θ
(Absolute deviations from baseline)

An increase in the overall "drug-acceptance" climate in Country A by one percent from initial probability value (π)

Country A's consumption share of domestically produced (θ)	0.555	0.655	0.755	**0.855 (Benchmark)**	0.955
Rate of (anti-)persistence ϕ					
0.1	0.0080	0.0080	0.0080	0.0078	0.0075
0.2	-0.0152	-0.0985	0.0534	0.0292	0.0246
0.3	-0.0023	-0.0062	-0.0132	-0.0241	-0.0290
0.4	-0.0009	-0.0036	-0.0076	-0.0123	-0.0135
0.5 (Benchmark)	-0.0004	-0.0028	-0.0062	**-0.0099**	-0.0107
0.6	-0.0002	-0.0024	-0.0056	-0.0090	-0.0097
0.7	0.0000	-0.0022	-0.0054	-0.0086	-0.0093
0.8	0.0001	-0.0021	-0.0052	-0.0084	-0.0091
0.9	0.0001	-0.0021	-0.0051	-0.0083	-0.0091

Does prohibitive supply-side policy work?

A decrease in the drug production capacity of drug syndicate in Country B (q)

	Initial Values	Benchmark	$\nu_A = -0.072$	$\nu_A = 0.072$	$\varsigma_\Xi = 0.3$	$\chi = 0.5$	$\rho = 0.5$	
Growth of tradable output in Country A	0.025	**0.0479**	0.0488	0.0466	0.1114	-0.0246	0.0357	
Growth of private consumption, Country A	0.025	**-0.0066**	-0.0066	-0.0065	-0.0051	-0.0066	-0.0079	
Growth of physical capital stock, Country A	0.025	**0.0479**	0.0488	0.0466	0.1115	-0.0246	0.0357	
Growth of tradable output in Country B	0.025	**0.0000**	0.0000	0.0000	0.0000	0.0000	0.0000	
Growth of private consumption, Country B	0.025	**0.0479**	0.0488	0.0466	0.1114	-0.0246	0.0357	
Growth of relative human capital stock, Country B	0.000	**0.0077**	0.0077	0.0077	0.0118	0.0077	0.0092	
Growth of current-period drug production	0.025	**-0.0066**	-0.0066	-0.0065	-0.0051	-0.0066	-0.0079	
Current-to-accumulated drug consumption ratio	0.525	**-0.0077**	-0.0077	-0.0077	-0.0118	-0.0077	-0.0092	
Price of drugs	7.500	**0.0048**	0.0048	0.0048	0.0074	0.0048	0.0579	
Growth of total guns production	0.025	**0.0479**	0.0488	0.0466	0.1114	-0.0246	0.0357	
Price of guns	4.120	**-0.0287**	-0.0287	-0.0287	-0.0252	-0.0287	-0.0032	

Note: All simulated policies represent a one percent shock from the initial value of the relevant policy arrangement.

More on supply-side intervention

More Prohibitive Supply-side Policy - Growth effects on Private Consumption in Country B:

Different value of χ and ϱ

(Absolute deviations from baseline)

A decrease in the drug production capacity of drug syndicate in Country B by one percent from initial probability value (q)

Country B' consumption share of domestically produced (ϱ)	0.5	0.6	0.7	**0.8 (Benchmark)**	0.9
Elasticity of guns' production wrt tradable inputs χ					
0.05 (Benchmark)	0.0286	0.0359	0.0423	**0.0479**	0.0530
0.10	0.0370	0.0480	0.0582	0.0679	0.0771
0.15	0.0605	0.0851	0.1128	0.1445	0.1809
0.20	0.1646	0.3849	0.6714	-0.1300	-0.4922
0.25	-0.2525	-0.1586	-0.1287	-0.1141	-0.1054
0.30	-0.0744	-0.0674	-0.0636	-0.0612	-0.0596
0.35	-0.0451	-0.0438	-0.0430	-0.0425	-0.0421
0.40	-0.0333	-0.0332	-0.0331	-0.0331	-0.0330
0.45	-0.0274	-0.0275	-0.0276	-0.0277	-0.0278
Structural break-point for χ, for a given consumption share of domestically-produced in Country B:	**0.225**	**0.214**	**0.200**	**0.193**	**0.186**
Indicative structural break-point for ω:	**0.775**	**0.786**	**0.800**	**0.807**	**0.814**

Is an elevated mark-up in drug price universally good?

drug-control intervention at the transhipment stage does have significant effect in the short-to-medium term in reducing drugs trade, though at the expense of some lost in consumption growth

Permanent increase in the price mark-up shift parameter for drug distribution
A one percent increase in κ_0 from initial value
(Absolute deviations from baseline)

	Initial Values	Benchmark	$\nu_A = -0.072$	$\nu_A = 0.072$	$\varsigma_\Xi = 0.3$	$\chi = 0.5$
Growth of tradable output in Country A	0.025	**-0.0157**	-0.0155	-0.0160	-0.0176	0.0228
Growth of private consumption, Country A	0.025	**-0.0016**	-0.0016	-0.0016	-0.0007	-0.0016
Growth of physical capital stock, Country A	0.025	**-0.0157**	-0.0155	-0.0160	-0.0176	0.0228
Growth of tradable output in Country B	0.025	**0.0000**	0.0000	0.0000	0.0000	0.0000
Growth of private consumption, Country B	0.025	**-0.0157**	-0.0155	-0.0160	-0.0176	0.0228
Growth of relative human capital stock, Country B	0.000	**0.0019**	0.0019	0.0019	0.0016	0.0019
Growth of current-period drug production	0.025	**-0.0016**	-0.0016	-0.0016	-0.0007	-0.0016
Current-to-accumulated drug consumption ratio	0.525	**-0.0019**	-0.0019	-0.0019	-0.0016	-0.0019
Price of drugs	7.500	**0.0662**	0.0662	0.0662	0.0660	0.0662
Growth of total guns production	0.025	**-0.0157**	-0.0155	-0.0160	-0.0176	0.0228
Price of guns	4.120	**0.0321**	0.0321	0.0321	0.0319	0.0321

Thank You

Appendix

A *dynamic international trade equilibrium* for the two-country model described is a sequence of consumption and labor supply allocations for household in Country A $\{C_t^A, C_t^{A,A}, C_t^{A,B}, L_t^A, \xi_t\}_{t=0}^{\infty}$ and individuals (in symmetry) in Country B $\{C_t^B, C_t^{B,B}, C_t^{B,A}, L_t^{T,B}, L_t^{\xi,B}\}_{t=0}^{\infty}$, physical capital stock in Country A $\{K_t^A\}_{t=0}^{\infty}$, accumulated stocks in Country B $\{H_{j,t}^{\xi,B}, H_{j,t}^{T,B}, \Xi_t\}_{t=0}^{\infty}$, productivity $\{Q_t^{T,A}, Q_t^{T,B}\}_{t=0}^{\infty}$, output $\{Y_t^{T,A}, Y_t^{T,B}, Y_t^{G,A}\}_{t=0}^{\infty}$, factor returns $\{w_t^{T,A}, r_t^{T,A}, w_t^{\xi,B}, w_t^{T,B}\}_{t=0}^{\infty}$, prices $\{P_t^T, P_t^{\xi}, P_t^G\}_{t=0}^{\infty}$, constant government policy parameters $(\tau_L, \tau_K, \tau_G, \nu)$ such that, given initial stocks $K_0^A, H_0^{\xi,B}, H_0^{T,B}, \Xi_0 > 0$, (a) representative household in Country A maximizes expected utility by choosing consumption allocations for ordinary tradables, drugs, and labor supply, subject to their intertemporal budget constraint;

(b) individuals in Country B maximize expected utility by choosing consumption allocations for ordinary tradables, labor supplies to both production sectors, investment in formal human capital, subject to their intertemporal budget constraint; (c) firms in the ordinary tradable goods sector in Country A maximize profits, choosing labor and private capital, taking input prices, productivity, and initial stocks as given; (d) the single guns-producing firm in Country A maximizes profits by choosing the amount of ordinary tradables to be used, taking the proprietary production technology and prices as given; (e) representative firm in Country B maximizes profits by choosing effective labor input, taking wages and productivity as given; (f) drug syndicate in Country B maximizes expected payoff by chooseing effective labor input and guns, taking prices, wage, and aggregate uncertainty as given; (g) the Government in Country A maintains a balanced budget; and (h) all markets clear.

A *balanced growth equilibrium* is a *DITE* in which, by implications of free trade, both Country A and B grow at a constant rate. For a given set of parameters, this means **(i)** the endogenous variables all grow at a constant rate γ, with the levels exhibit steady-state properties. This implies that **(ii)** $\Phi_t^{\xi\Xi} = \xi_t/\Xi_t$, $\Phi_t^{C_A\xi} = C_t^A/\xi_t$, $\Phi_t^{Y_{TA}K_A} = Y_t^{T,A}/K_t^A$, $\Phi_t^{C_AK_A} = C_t^A/K_t^A$, $\Phi_t^{G_GK_A} = G_t^G/K_t^A$, $\Phi_t^{G_FK_A} = G_t^F/K_t^A$, $\Phi_t^{Y_{TB}K_A} = Y_t^{T,B}/K_t^A$, $\Phi_t^{Y_{TB}H_B} = Y_t^{T,B}/H_t^{T,B}$, $\Phi_t^{H_BK_A} = H_t^{T,B}/K_t^A$, $\Phi_t^{C_BK_A} = C_t^B/K_t^A$, $\Phi_t^{Y_{TB}\xi} = Y_t^{T,B}/\xi_t$ are all constant $\forall t$; **(iii)** factor returns, wages, and prices are constant, and by implications, **(iv)** P_t^ξ/P_t^T and P_t^G/P_t^T are also constant.