NOTTINGHAM TRENT UNIVERSITY

DISCUSSION PAPERS IN ECONOMICS

No. 2019/1 ISSN 1478-9396

MODELING THE DRUGS AND GUNS TRADE IN A TWO-COUNTRY MODEL WITH ENDOGENOUS GROWTH

KING YOONG LIM

DIEGO MORRIS

JANUARY 2019

DISCUSSION PAPERS IN ECONOMICS

At Nottingham Business School, our Working Papers Series in Economics include a wide variety of approaches reflecting our research interests and academic expertise.

This paper is part of the new series, ***Discussion Papers in Economics***.

Earlier papers can be found at:
https://www.ntu.ac.uk/research/research-at-ntu/academic-schools/research-at-nottingham-business-school/nbs-working-papers

Please contact the Editor (maternity cover) for enquiries concerning any of our Discussion Papers:

King Yoong Lim
Division of Economics
Nottingham Trent University
50 Shakespeare Street
Nottingham NG1 4FQ
UNITED KINGDOM

Email: king.lim@ntu.ac.uk
Tel: + 44 (0)115 848 6071

Modeling the drugs and guns trade in a two-country model with endogenous growth

King Yoong Lim* and Diego Morris**

This Version: September 1, 2018

Abstract

This paper develops a two-country, dynamic general equilibrium model of endogenous growth with illicit drugs and guns trade. With a trade framework that unifies both drug-control policies in consuming- and producing-country, as well as explicit modeling of firearm trade, the model is solved and parameterized to study the dynamic trade-off and growth effects of various drug-control policies. A *production-consumption* growth trade-off not previously documented in the literature is found. Further, under different conditions, and depending on the resulting gain in formal trade expansion, there are economic rationale to either a prohibitive or liberalization drug-control policy.

JEL Classification Numbers:
Keywords: Endogenous Growth, Drugs, Illicit Trade, Organized Crime.

*Corresponding author, Nottingham Business School, Nottingham Trent University. Email: king.lim@ntu.ac.uk; **Nottingham Business School, Nottingham Trent University. We thank Kwok Tong Soo for his ideas and suggestions during the initial conceptualization of the study. The views expressed are our own.

1 Introduction

Drug trade-related criminal gangs and crime has escalated across Central America and the Caribbean over the past two decades.[1] The region's location between the United States (U.S.), which is the principal consumer nation, and the illicit-crop farming Andean nations, combined with increased drug production and interdiction in the Caribbean, has made Central America a key illicit drug hub. Indeed, as documented in the various editions of the *World Drug Report* (for instance, UNODC 2014-18), about 90% of the cocaine consumed in the U.S. crosses the land border between Mexico and the United States, with the large majority of that flow crossing through or along the Pacific and Atlantic coasts of Central America.

The links between drugs, guns, and crime are the subject of a substantial literature, most of which focuses on the U.S. and Central America [see, for instance, Miron (2001), Demombynes (2011)]. If the illicit drug trade brings more criminal gangs and guns or heavier weapons into an area, their easy availability could facilitate crime, both related and not related to the drugs trade. Research in the U.S. has suggested that crime was prevalent around the period of the crack epidemic in the U.S. because the trade fueled demand for guns, leading to diffusion of guns in the illicit market (Blumstein 1995; Blumstein et al. 2000). In its report, the Latin American Commission on Drugs and Democracy (2016) highlighted this linkage: "*the relationship between homicide, firearm, and drug commerce is central. Drugs finance the purchase of firearms, which in turn are used as indirect factors of drugs production and trafficking.*"

In addition, since Richard Nixon formally declared a war on drugs in 1971, different policies have been implemented in both consumer and producer countries with the

[1] For instance, Langton (2011) documented the rise of the Mexican drug cartels and implies their dominant role in the illicit drugs and firearms trade in the region. Similarly, the role of Central America-based organized drug syndicates in the illicit markets are also documented in Bagley (2012) and Bagley and Rosen (2015). More recently, the controversial issue with regards to the rise of drug syndicates, MS-13 and M-8, in the United States can be found in several press reports. For example, see https://www.bbc.co.uk/news/world-us-canada-39645640.

goal of reducing illegal drugs' consumption (Whitford and Yates 2009). Several anti-drug strategies, ranging from the eradication of illicit crops, the detection and destruction of processing labs, the interdiction of drug shipments en-route to consumer markets, and outright legalization against drug possession have been implemented. However, mixed results are observed. In LSE (2014), it is argued that 'drug free world' ideology that underpins these strategies have been counter-productive, therefore requiring a fundamental restructuring of drug-control policies to combat the highly-persistent illicit drugs trade.

Furthermore, a number of researchers have argued that under certain conditions, aggressive drug enforcement may potentially amplify crime. For instance, Becker et al. (2006) note that if the demand for drugs is inelastic, increased enforcement will increase the price and reduce consumption, but will also increase the total resources available to drug syndicates. Likewise, in Ortiz (2003, 2009), drug policy ineffectiveness is due to drug producers responding by improving productivity to compensate for the increased repression. Under these conditions, facing robust revenue, drug syndicates are better equipped to further purchase weapons to aid their illicit trades. Evidence for this hypothesis comes from a long-term look at the evolution of crime rate in the U.S.: Dills et al. (2010) show that increases in enforcement of drug prohibition in the U.S. over the past 100 years have been associated with increases in crime rate.

Against this backdrop, there is also an active debate amongst policymakers and researchers alike about greater liberalization of drug policy. As an example, Portugal undertook a monumental experiment: it decriminalized the use of all drugs in 2001, even heroin and cocaine, and unleashed a major public health campaign to tackle addiction. Ever since in Portugal, drug addiction has been treated more as a medical challenge than as a criminal justice issue. The results from this experiment suggest a stark dichotomy with the tough stance of the U.S., with some argued that it works better. Perhaps, proponents of such arguments have lead to the increasing number of American states legalizing the possession of non-medical cannabis in recent years, despite laws at the Federal level remaining largely prohibitive.[2]

This dichotomy in drug management approach underline the general difficulties in assessing the economic impact and trade-off associated with various drug-control policies, more so if one were to understand the intricate nexus and externalities between the illicit trades and the formal tradable sectors. To date, the existing theoretical literature on macroeconomics of drugs have focused mainly on modelling the vertical supply-chain of drugs, and therefore suffers from three shortcomings, namely: (i) limited number of dynamic general equilibrium models that allow for the examination of growth effects and potential policy trade-off for the different stages of drug-control intervention ; (ii) the modelling of consumers' optimizing choice of drug consumption and addiction, as well as those of drugs' transhipment and production, tend to be completely separate; (iii) the non-adoption of a trade framework, as well as the absence of explicitly modeling of illicit firearm trades, means the various spillover and externalities between the illicit trades and productive formal trades cannot be studied.

To address these, we adopt a horizontal perspective to model the illicit drugs and guns trade by developing a unified endogenous growth framework with international trade and drugs control that also accounts for consumers' rational addiction and optimizing choice of drug consumption. Specifically, a two-country, multi-sectorial dynamic general equilibrium model of endogenous growth with drugs and guns trade is developed, solved both analytically and computationally, with the parameterized version, an illustrative 'source' economy based on five regional developing economies (El Salvador, Guatemala, Honduras, Jamaica, and Mexico) that are controversially known as 'nest' of illicit drugs and guns trade to/from the U.S.) used to simulate various drug-control policy experiments.

To preview our results, while prohibitive drug-control policy (both at the end-consumer and supply side) is trade- and growth-enhancing to the formal sector, we uncover a *pro-*

[2] Colorado and Washington became the first states to legalize possession of non-medical cannabis. These are subsequently followed by several states in the U.S.

duction-consumption growth trade-off that has not been previously documented in the literature, in that, if private consumption growth-maximization is prioritized in the consuming country over output growth, there is rationale for drug liberalization. Indeed, the policy effect is nonlinear in that, the more open the consuming country is (a larger share of imported tradables in final consumption), the wider the range of initial rational-addiction condition that would allow drug liberalization policy to be output growth-enhancing (instead of growth-deteriorating). In addition, in the absence of any fundamental change to world drug demand and supply, our policy experiments find neither a more intensified intermediary-interdiction policy (at drug transhipment) nor any non-quota gun-control policy (such as a tax levied on production), is effective in reducing the illicit trades for drugs and guns. A more direct supply-side policy aimed at eradicating drug cultivation appears to be more effective in raising formal trades and growth, though the effectiveness—as well as whether households in the source country that partly involve in drugs trade, albeit implicitly, can be compensated via the resulting (formal) *international-trade expansion* effect—depend a lot on the openness of the source country. We believe some of these findings provide partial explanation on the mixed outcome observed from the global war on drugs over the past few decades.

The rest of the paper are structured as follows. Section 2 describes the theoretical model. Section 3 defines the dynamic and balanced growth equilibrium, and then proceeds to solve the model. In Section 4, the parameterization strategy is dicussed. After that, various illustrative drug-control policy experiments are presented in Section 5, with the sub-sections being structured according to different policy theme and questions. Section 6 concludes the paper.

2 The Model

We examine the controversial drugs-guns trade using a theoretical framework of a two-country dynamic general equilibrium model with international trade. Country A is a relatively 'developed' economy populated by a representative household who consumes ordinary tradable goods (domestically produced and traded from Country B) and drugs—the latter modelled as a rationally addicted good that is not produced in Country A. Firms in Country A produces ordinary tradable goods using labor and physical capital supplied by households. There is also a price-taking firm producing guns, using a proprietary technology and inputs of domestically produced ordinary tradables.[3] Due to legal restriction, the guns produced are not sold to the household, but exported to Country B and purchased by the Government in Country A. The Government taxes labor and capital income, as well as the sales of guns. While the Government discourages consumption of drugs by confiscating them at a random probability in each period, consumption of drugs is not deemed as criminal offense.

Country B is a developing economy populated by identical individuals and a drug syndicate. Individuals do not hold physical capital, consume ordinary tradables (domestically produced and traded from Country A), and do not consume drugs. Instead, they supply labor hours to both a representative firm in the formal sector producing ordinary tradables, as well as a drug syndicate who produces drugs. Production activities in Country B are human capital-driven, with the individuals having a choice to invest in formal/legal human capital each period, a feature similar to Mocan et al. (2005). The drug syndicate is modelled as a stylized agent similar in fashion to Blackburn et al. (2017) and related studies[4], who maximizes its expected payoff by producing drugs using guns (traded from

[3] Alternatively, one can argue that the production of guns requires the use of physical capital. Given that the ordinary tradables produced in Country A have already used both labor and physical capital as inputs, specifying guns as being a transformation of ordinary tradables would have the same interpretation. Instead, productivity of guns-production benefits from an Arrow-Romer type of knowledge spillover embedded in the physical capital stock in Country A.

[4] In practice, organized drug syndicates tend to have much more sophisticated structure, as documented

Country A) and effective labor hours, where productivity depends on the average level of drug-specific human capital (interpretable as some sort of cultural capital that benefits specifically drugs production) that in equilibrium, equals the accumulated stock of drugs addiction in Country A. Our specification for Country B essentially 'merges' the production chains of illicit-crop farming and drug trafficking into a single drug syndicate, as compared to the vertically-integrated model of Mejía and Restrepo (2016). Nevertheless, given that most mechanisms (in the different vertical production chains) in their model operate through resource (re-)allocation, the differences—in terms of transmission mechanisms—of our simplified specification for Country B are largely immaterial in a long-run context. Instead, we trade some of the vertical features off for a greater horizontal perspective on the illlicit drugs and guns trades, by developing a two-country, multi-sectorial dynamic general equilibrium framework that is solvable for a balanced growth equilibrium, hence allowing for the examination of dynamic tradeoff and long-run growth implications of drug-control policies.

2.1 Country A

Country A Household: The representative household in Country A faces a risk neutral expected lifetime utility, which depends on the chosen sequences of consumption of ordinary tradable goods (a bundle of tradable home good and imported good), C_{t+s}, labor, L_{t+s}, and the consumption of drugs, ξ_{t+s}, for $s = 0, 1, ..., \infty$, as in

$$U_t = \mathbb{E}_t \sum_{s=0}^{\infty} \Lambda^s \left(\frac{(C_{t+s}^A)^{1-\varsigma_{CA}^{-1}}}{1-\varsigma_{CA}^{-1}} - \frac{\eta_L}{1+\psi} L_{t+s}^{1+\psi} + \pi \frac{[\xi_{t+s}(\Xi_{t+s})^{\eta_\Xi}]^{1-\varsigma_\Xi^{-1}}}{1-\varsigma_\Xi^{-1}} \right), \tag{1}$$

where C_t^A is consumption, $\varsigma_{CA} > 0$ intertemporal elasticity of substitution in consumption, $L_t = \int_0^1 L_t^i di$, the share of total time endowment (normalized to unity) spent working, with L_t^i denoting the number of hours of labor provided to the i firms, $\Lambda \in (0, 1)$ the subjective

in contributions such as Levitt and Venkatesh (2000) and similar case studies. In a two-country, multi-sectorial general equilibrium framework, some of these features are abbreviated.

discount factor, Ξ_t is the period t stock of accumulated past drugs consumption taken as given by household, $\mathbb{E}_t$ the expectation operator conditional on the information available at the beginning of period t. Instantaneous utility is therefore additively separable in terms of the consumption of ordinary tradable goods and drugs.[5]

In each period t, the representative household faces a constant probability, π, where the possession of drugs evades confiscation, and probability, $1-\pi$, where the drugs are confiscated by the government. For simplicity, if the drugs are confiscated, drug possession is assumed to be not a criminal offense and the household merely gets zero utility from ξ_t and does not go to jail.[6]

In line with the tradition of Becker and Murphy (1988), we assume addiction is both time-consistent and rational, and the utility generated from drugs consumption depends on both current and past accumulated consumption.[7] Specifically, the stock of past consumption, Ξ_t, is specified to evolve according to

$$\Xi_{t+1} = (1-\phi)\Xi_t + \xi_t, \tag{2}$$

or equivalently,

$$\frac{\Xi_{t+1}}{\Xi_t} = (1-\phi) + \frac{\xi_t}{\Xi_t}, \tag{3}$$

where $\phi \in [0,1]$ measures the degree of persistence of the addiction from accumulated past consumption of drugs. If $\phi = 0$, past addiction does not diminimish over time, while $\phi = 1$ means drugs consumptions in the past do not influence the accumulation/addiction

[5]In spite of the additive separable functional form, current-period drug consumption (ξ_t) is quasi-complementary to past accumulated consumption (Ξ_t), a key feature that is consistent with the rational addiction literature in the tradition of Becker and Murphy (1988), with relatively more sophisticated utility specification of rational addiction further discussed in Gruber and Köszegi (2001). The specification of the constant probability, π, is also in consistent with most macroeconomic models of crime, such as Imrohoroğlu et al. (2004, 2006).

[6]While debatable, the simplification in assuming drug as not a imprisonable offense is in line with empirical evidence such as Kuziemko and Levitt (2004), which documented that the overall impact of increased drug incarceration has been very small in reducing the criminal incidence.

[7]In microeconomic studies focusing on cigarettes' addiction, such as O'Donoghue and Rabin (1999) and Gruber and Koszegi (2001), agents with time-inconsistent optimization problem are considered. They also consider the self-control problem of a sophisticated agent, whose consumption decision is modelled as a subgame-perfect equilibrium in a dynamic game played by the successive intertemporal selves. These are not considered here.

process.

In addition to supply labor (in effective terms, $A_t^{T,A}L_t^{T,A}$) services, household also owns physical capital and therefore earns income by supplying physical capital and labor services at each period t, taxed at a constant rate of τ_K and τ_L respectively. Similar to studies with tradable goods framework, such as Agénor (2016), consumption decisions on ordinary tradable goods follow a two-step process: first, the optimal path of total consumption over time is determined, the amount from which is then allocated between spending on domestic and foreign tradables. The representative household maximizes (1) by choosing the optimal sequences of ordinary tradable consumption, C_t^A, labor, L_t, drugs consumption, ξ_t, and the physical capital stock to hold in the next period, K_{t+1}, subject to the end-of-period budget constraint of

$$(1-\tau_L)w_t^{T,A}A_t^{T,A}L_t^{T,A} + (1-\tau_K)r_t^{T,A}K_t = P_t^T(C_t^A + I_t) + P_t^{\xi}\xi_t, \tag{4}$$

where

$$K_{t+1} = (1-\delta^K)K_t + I_t, \tag{5}$$

taking wages ($w_t^{T,A}$), labor productivity ($A_t^{T,A}$), real interest rate ($r_t^{T,A}$), the tax rates, price of tradable goods (P_t^T), and price of drugs (P_t^{ξ}) as given.

In Appendix A, we solve for the first-order conditions and derive the followings:

$$\frac{\mathbb{E}_t C_{t+1}^A}{C_t^A} = \left\{ \frac{1}{\Lambda} \frac{\mathbb{E}_t P_{t+1}^T}{P_t^T} [(1-\tau_K)\mathbb{E}_t r_{t+1}^{T,A} + (1-\delta_K)] \right\}^{-\varsigma_{CA}}, \tag{6}$$

$$\frac{\mathbb{E}_t \xi_{t+1}}{\xi_t} = \left\{ \frac{1}{\Lambda} \left(\frac{\mathbb{E}_t \Xi_{t+1}}{\Xi_t} \right)^{\frac{\varsigma_\Xi}{\eta_\Xi(\varsigma_\Xi - 1)}} \frac{\mathbb{E}_t P_{t+1}^{\xi}}{P_t^{\xi}} [(1-\tau_K)\mathbb{E}_t r_{t+1}^{T,A} + (1-\delta_K)] \right\}^{-\varsigma_\Xi}, \tag{7}$$

$$\eta_L L_t^{\psi} = \frac{(C_t^A)^{-\varsigma_{CA}^{-1}}}{P_t^T}(1-\tau_L)w_t^{T,A}A_t^{T,A}. \tag{8}$$

$$P_t^{\xi} = \pi(\Xi_t)^{\eta_\Xi(1-\varsigma_\Xi^{-1})}\xi_t^{-\varsigma_\Xi^{-1}}(1-\tau_L)\frac{w_t^{T,A}A_t^{T,A}}{\eta_L L_t^{\psi}}. \tag{9}$$

Equation (6) is the Euler equation associated with ordinary consumption; equation (7) is the corresponding version for drug consumption (which depends on the growth of the total stock of past consumption, Ξ_{t+1}/Ξ_t, given by (3); equation (8) describes the marginal rate of substitution between labor supply and ordinary tradable consumption; (9) is the optimality condition for the marginal rate of substitution between drugs consumption and labor supply.

Combining (8) and (9), the ordinary-drugs consumption ratio of the representative household is given by

$$\frac{C_t^A}{\xi_t} = \pi^{-\varsigma_{CA}}(\Xi_t)^{\frac{\varsigma_{CA}}{\varsigma_\Xi}[\eta_\Xi(1-\varsigma_\Xi)+1]}(\frac{\xi_t}{\Xi_t})^{\frac{\varsigma_{CA}}{\varsigma_\Xi}}(\frac{P_t^\xi}{P_t^T})^{\varsigma_{CA}}, \tag{10}$$

which depends on the accumulated stock of past drugs consumption, the evasion probability, as well as the relative market price ratio of the two "goods".

Nominal consumption spending on non-addictive, ordinary tradable goods is $P_t^T(C_t^{A,A}+C_t^{A,B})$, where $C_t^{A,A}$ is consumption of ordinary tradables home good and $C_t^{A,B}$ the imported tradables from Country B. Total consumption is therefore a bundle,

$$C_t^A = (C_t^{A,A})^\theta (C_t^{A,B})^{1-\theta}, \tag{11}$$

where $\theta \in (0,1)$. The second stage of the optimization problem for the representative household is therefore to maximize (11) subject to a static budget constraint of $C_t = P_t^T C_t^{A,A} + P_t^T C_t^{A,B}$, which yields an optimal consumption allocation between Country A's ($C_t^{A,A}$) and Country B's tradables ($C_t^{A,B}$) for the household in Country A:

$$\frac{C_t^{A,B}}{C_t^{A,A}} = \frac{1-\theta}{\theta}. \tag{12}$$

Country A Production: The tradable goods are produced by a continuum of identical perfectly competitive firms $i \in (0,1)$, using effective labor, $A_t^{T,A} L_t^{i,T,A}$ (where $A_t^{T,A}$ is labor productivity), and private physical capital, $K_t^{i,A}$. The production function of firm i is given by

$$Y_t^{i,T,A} = Q_t^{i,T,A}(A_t^{T,A}L_t^{i,T,A})^{\beta}(K_t^{i,A})^{1-\beta}, \tag{13}$$

where the productivity of firms i, $Q_t^{i,T,A}$, evolves according to the sectorial-wide physical capital intensity. Specifically, productivity of firm i is subject to a sector-wide Arrow-Romer type of externality from the total stock of physical capital, congested by the total employment in the sector (in raw terms), as in

$$Q_t^{i,T,A} = Q_0^{T,A}[\frac{K_t^A}{L_t^{T,A}}]^{\varpi_T}, \tag{14}$$

where $K_t^A = \int_0^1 K_t^{i,A}di$, $\varpi_T > 0$.

The profit maximization problem for each firm i involves maximizing

$$\Pi_t^{i,T,A} = P_t^T Y_t^{i,T,A} - w_t^{T,A}(A_t^{T,A}L_t^{i,T,A}) - r_t^{T,A}K_t^{i,A},$$

with respect to the private inputs, taking production function, productivity, and input prices as given. This yields:

$$A_t^{T,A}w_t^{T,A} = \frac{\beta P_t^T Y_t^{i,T,A}}{L_t^{i,T,A}}, \quad r_t^{T,A} = (1-\beta)\frac{P_t^T Y_t^{i,T,A}}{K_t^{i,A}}. \tag{15}$$

In a symmetric equilibrium, given that all firms are identical, we have $Q_t^{T,A} = Q_t^{i,T,A}$, $K_t^A = K_t^{i,A}$, and $Y_t^{T,A} = Y_t^{i,T,A} \forall i$, which yields the aggregate tradable output produced in Country A:

$$Y_t^{T,A} = \int_0^1 Y_t^{i,T,A}di = Q_t^{T,A}(A_t^{T,A}L_t^{T,A})^{\beta}(K_t^A)^{1-\beta}, \tag{16}$$

or equivalently, after substituting in (14),

$$Y_t^{T,A} = Q_0^{T,A}(A_t^{T,A})^{\beta}(L_t^{T,A})^{\beta-\varpi_T}(K_t^A)^{1-\beta+\varpi_T}. \tag{17}$$

Further, the labor productivity level, $A_t^{T,A}$, is specified as influenced by drugs consumption, as in

$$A_t^{T,A} = A_0^A(\frac{\xi_t}{\Xi_t})^{\upsilon_A}, \tag{18}$$

where $A_0^A > 0$, and $\upsilon_A \in \mathbb{R}$ measures the strength of the drugs' effects on labor productivity. A positive elasticity indicates positive effect from present-accumulated drug consumption on labor productivity (a sort of *stimulant effect*), while a negative elasticity indicates an adverse effect of drugs consumption (as a share of past accumulated consumption) on labor productivity.

Substituting (18) into (17), we can write

$$Y_t^{T,A} = Q_0^{T,A}(A_0^A)^\beta (\frac{\xi_t}{\Xi_t})^{\upsilon_A \beta}(L_t^{T,A})^{\beta-\varpi_T}(K_t^A)^{1-\beta+\varpi_T}. \tag{19}$$

Likewise, using the two first-order conditions in (15), we derive a ratio of the factor prices in Country A as

$$\frac{w_t^{T,A}}{r_t^{T,A}} = \frac{\beta}{1-\beta}\frac{K_t^A}{L_t^{T,A}}\frac{1}{A_t^{T,A}},$$

or equivalently, by substituting in (18),

$$\frac{w_t^{T,A}}{r_t^{T,A}} = \frac{\beta}{1-\beta}\frac{K_t^A}{L_t^{T,A}}(A_0^A)^{-1}(\frac{\xi_t}{\Xi_t})^{-\upsilon_A}. \tag{20}$$

Assumption: $\beta = \varpi_T$. To derive *endogenous growth*, we restrict our analysis by imposing the assumption, which then allows us to write (19) as a ratio of the ordinary tradables to physical capital in Country A:

$$\frac{Y_t^{T,A}}{K_t^A} = Q_0^{T,A}(A_0^A)^\beta (\frac{\xi_t}{\Xi_t})^{\upsilon_A \beta}. \tag{21}$$

Guns production: Due to legal restriction, guns are produced by a single firm in Country A. The production of guns is taxed by the government at a constant rate of τ_G. Guns are not sold to households. Instead, guns are exported to Country B and sold to the Government for Country A. The price of guns, P_t^G, is set by the world market (given the two-country context, this means the demand of buyers from Country B), with the purchase of the Goverment for Country A following the same world price.[8] The guns-producing

[8]With this specification, we essentially treats all illicit component of world gun trades as the exported

firm has a proprietary production technology of

$$Y_t^{G,A} = A_t^G (Y_t^{T,AG})^{\varkappa}, \tag{22}$$

where $\varkappa \geq 0$, $Y_t^{T,AG}$ is the quantity of ordinary tradables used in guns' production, and A_t^G is a productivity parameter given by $A_t^G = A_0^G (K_t^A)^{\omega}$, where similar to ordinary tradable production, the productivity of the firm benefits from knowledge spillover embedded in the aggregate physical capital stock of the economy, at a rate $\omega > 0$.

Given the tax rate and the perfectly competitive market for physical capital, the profit maximization problem for the guns-producing firm is simply given by the unconstrained maximization problem of:

$$\max_{Y_t^{T,AG}} (1 - \tau_G) P_t^G Y_t^{G,A} - P_t^T Y_t^{T,AG},$$

with $Y_t^{G,A}$ given by (22), which yields the first-order condition for the demand of ordinary tradables in gun-production

$$Y_t^{T,AG} = \left[\frac{(1 - \tau_G) P_t^G A_0^G \varkappa}{P_t^T} \right]^{\frac{1}{1-\varkappa}} (K_t^A)^{\frac{\omega}{1-\varkappa}}. \tag{23}$$

Assumption: $\omega = 1 - \varkappa$. Again, to get endogenous growth, we restrict our analysis by imposing the assumption to rewrite (23) in the AK-form of

$$\frac{Y_t^{T,AG}}{K_t^A} = \left[(1 - \tau_G) A_0^G \varkappa \right]^{\frac{1}{1-\varkappa}} \left(\frac{P_t^G}{P_t^T} \right)^{\frac{1}{1-\varkappa}}. \tag{24}$$

Government of Country A: The government in Country A does not borrow and maintains a balanced budget in each period t. The government collects taxed income from the labor and physical capital, as well as from total guns production $(P_t^G Y_t^{G,A})$. The government spends on consumption of domestically produced ordinary tradables (G_t^A),

share, while the purchase made by the government in Country A is interpreted as all other legal purchases. As such, given that the government has imperfect information on the international buyer of guns, it is reasonable to levy any tax rate of guns at the production stage, and not sales stage.

guns produced in Country A (G_t^G). In addition, the government has a probability $1-\pi$ in detecting and confiscating drugs from the household, which has a realizable value and gives an additional "rebate" received in each period, R_t. For simplicity, we assume that the rebate is a fraction, $z \in (0,1)$ of the confiscated drugs:

$$R_t = z(1-\pi)P_t^{\xi}\xi_t. \tag{25}$$

The budget constraint of the government is therefore given by

$$\tau_L w_t^{T,A} A_t^{T,A} L_t^{T,A} + \tau_K r_t^{T,A} K_t + \tau_G P_t^G Y_t^{G,A} + R_t = P_t^T G_t^A + P_t^G G_t^G. \tag{26}$$

Without losing generality, government consumption of the ordinary tradables is assumed to be a fixed fraction of the domestic households' consumption,

$$G_t^A = \nu C_t^{A,A}, \nu \in (0,1). \tag{27}$$

2.2 Country B

Country B Individuals: In Country B, there is a unit mass of identical individuals $j \in (0,1)$. Each individual j is endowed with one unit of time in each period t, and for simplicity, individuals do not value leisure in Country B and time is fully allocated to between working in the tradable sector and working for the drug syndicate, in that $L_{j,t}^{T,B} + L_{j,t}^{\xi,B} = L_{j,t}^B$, where $L_{j,t}^B = 1$. Nevertheless, individuals do face some degree of disutility from working, interpretable as due to poor working conditions. Individuals in Country B consume ordinary tradables and are assumed to not consume drugs. Wage income is paid to effective labor in both sectors in that it is influenced by the level of human capital/productivity, though individuals can only invest in formal human capital. In other words, investment in the level of formal human capital that is useful in ordinary tradable production, $H_{j,t}^{T,B}$, is a choice variable. Each individual j therefore chooses a sequence of investment, $I_{j,t+s}^{T,B}$ (in tradable price), total consumption, $C_{j,t+s}^B$, the labor hours supplied to both ordinary tradable sector ($L_{j,t+s}^{T,B}$) and the drug syndicate ($L_{j,t+s}^{\xi,B}$), for $s = 0, 1, ..., \infty$, to maximize expected utility,

$$\max V_t^j = \mathbb{E}_t \sum_{s=0}^{\infty} \Lambda^s \left[\frac{(C_{j,t+s}^B)^{1-\varsigma_{CB}^{-1}}}{1-\varsigma_{CB}^{-1}} - \frac{\eta_B}{1+\psi_B} (L_{j,t}^{T,B} + L_{j,t}^{\xi,B})^{1+\psi_B} \right], \tag{28}$$

where $\Lambda \in (0,1)$ the common subjective discount factor, $\varsigma_{CB} > 0$ intertemporal elasticity of substitution in consumption, and $\eta_B > 0$, subject to an end-of-period flow budget constraint of

$$w_t^{T,B} H_{j,t}^{T,B} L_{j,t}^{T,B} + w_t^{\xi,B} H_{j,t}^{\xi,B} L_{j,t}^{\xi,B} + \xi_j J_t^{T,B} = P_t^T (C_{j,t}^B + I_{j,t}^{T,B}), \tag{29}$$

and the time constraint $L_{j,t}^{T,B} + L_{j,t}^{\xi,B} = L_{j,t}^B$, taking the profits received from owning the representative firm, J_t^{TB} [$\xi_j \in (0,1)$ being the fraction of the profits claimed by individual j] , the respective real wage for employment in the ordinary tradable and drugs production sector, $w_t^{T,B}$ and $w_t^{\xi,B}$, the average drug-specific productivity level, $H_{j,t}^{\xi,B}$, and the tradable price, P_t^T, as given.

The human capital of individual j evolves according to

$$H_{j,t+1}^{T,B} = \Theta_{HB} I_{j,t}^{T,B} + (1 - \delta^{HB}) H_{j,t}^{T,B}, \tag{30}$$

where $\Theta_{HB} > 0$ is the efficiency of human capital investment and $\delta^{HB} \geq 0$ is the depreciation rate of human capital.

Solving an individual j's optimization problem yields the first-order conditions:

$$\left(\frac{\mathbb{E}_t C_{j,t+1}^B}{C_{j,t}^B} \right)^{\varsigma_{CB}^{-1}} = \Lambda \left[\frac{\Theta_{HB} w_{t+1}^{T,B} H_{j,t+1}^{T,B}}{P_{t+1}^T} + (1 - \delta^{HB}) \right], \tag{31}$$

$$L_{j,t}^{T,B} + L_{j,t}^{\xi,B} = \left[\frac{(C_{j,t}^B)^{-\varsigma_{CB}^{-1}}}{P_t^T \eta_B} w_t^{T,B} H_{j,t}^{T,B} \right]^{1/\psi_B}, \tag{32}$$

$$H_{j,t}^{T,B} w_t^{T,B} = H_t^{\xi,B} w_t^{\xi,B}. \tag{33}$$

Consumption decisions follow a two-step process too. Let $C_{j,t}^{B,B}$ is consumption of ordinary tradables home good and $C_{j,t}^{B,A}$ the imported tradables from Country A. Total consumption of each individual j in Country B is therefore a bundle,

$$C_{j,t}^{B} = (C_{j,t}^{B,B})^{\varrho}(C_{j,t}^{B,A})^{1-\varrho}, \tag{34}$$

where $\varrho \in (0,1)$. The second stage of the optimization problem for each individual j is therefore to maximize (34) subject to a static budget constraint of $C_t^B = P_t^T C_t^{B,B} + P_t^T C_t^{B,A}$, which yields an optimal consumption allocation of:

$$\frac{C_t^{B,A}}{C_t^{B,B}} = \frac{1-\varrho}{\varrho}. \tag{35}$$

For simplicity, we assume that, similar to consumption allocation, in each period t, individuals in Country B further solves a static labor allocation problem, where each individual j maximizes $L_{j,t}^{B} = (L_{j,t}^{T,B})^{\vartheta}(L_{j,t}^{\xi,B})^{1-\vartheta}$, subject to the time constraint, $L_{j,t}^{T,B} + L_{j,t}^{\xi,B} = L_{j,t}^{B} = 1$. This gives an optimal allocation of:

$$\frac{L_{j,t}^{\xi,B}}{L_{j,t}^{T,B}} = \frac{1-\vartheta}{\vartheta}. \tag{36}$$

Country B production: The tradable goods are produced by a price-taking representative firm using only labor. The production technology is constant returns-to-scale and given by

$$Y_t^{T,B} = Q_t^{T,B}(H_t^{T,B} L_t^{T,B})^{\alpha}, \tag{37}$$

where $H_t^{T,B}$ and $L_t^{T,B}$ are the average human capital level and total labor hours employed in the tradable sector.

Productivity of the ordinary tradables-producing firm in Country B, $Q_t^{T,B}$, is assumed to depend linearly on a scale factor from its trading partner, proxied by the ordinary tradable output-to-physical capital ratio of Country A, as well as an Arrow-Romer spillover effect from the (aggregate) stock of formal human capital in Country B, at a magnitude $\phi_1 \geq 0$. Specifically,

$$Q_t^{T,B} = Q_0^B (H_t^{T,B})^{\phi_1} \frac{Y_t^{T,A}}{K_t^A}. \tag{38}$$

As would become clear in the policy experiments section later, this specification means *growth* in Country B's tradable production can only be driven by growth in $H_t^{T,B}$ [indirectly, policy parameters in (30)] in the steady state, as any other change in policy arrangements will be growth-neutral and only bring about *level* effect on tradable production in Country B. The deliberate choice is to capture some of the well-documented persistency in the mediocre growth rates observed in many of the source country for drugs cultivation [see, for instance, LSE (2014) and Buxton (2015)].

Solving the firm's profit maximization problem, $\max_{L_t^{T,B}} \pi_t^{T,B} = P_t^T Y_t^{T,B} - w_t^{T,B} H_t^{T,B} L_t^{T,B}$, yields the first-order condition of

$$\frac{\alpha P_t^T Y_t^{T,B}}{L_t^{T,B}} = w_t^{T,B} H_t^{T,B}. \tag{39}$$

Given that individuals are identical, we know that the average and individual-specific productivity level in the economy is the same, $H_t^{T,B} = H_{j,t}^{T,B}$.

Assumption: $\phi_1 + \alpha = 1$. To eventually generate endogenous growth for the ordinary tradable output in Country B, we impose the assumption and rewrite (37) as

$$\frac{Y_t^{T,B}}{H_t^{T,B}} = Q_0^B \frac{Y_t^{T,A}}{K_t^A} (L_t^{T,B})^{\alpha}. \tag{40}$$

Drug Syndicate: Similar to Blackburn et al. (2017) and other similar studies in the literature of organized crime, such as Alexeev et al. (2004) and Kugler et al. (2005), the drugs sector is modelled as an independent entity from the households in Country B. In other words, the crime syndicate is modelled as a rational decision maker whose sole objective is to maximise its expected payoff from producing drugs, $E(v_t^{\xi})$. For simplicity, we assume the crime syndidate does not consume ordinary tradables.

The drugs' production technology is given by

$$\xi_t = A_0^R (H_t^{\xi,B} L_t^{\xi,B})^{\varphi} (G_t^F)^{1-\varphi}, \tag{41}$$

where $\varphi \in (0,1)$, and $A_0^R > 0$ is a time-invariant constant productivity level of the drugs-producer. $H_t^{\xi,B} L_t^{\xi,B}$ is the effective labor hours used in producing drugs, with a one-to-one relationship assumed between drug-specific human capital (which is akin to a type of cultural capital that is common across all workers working in drugs production) and the total accumulated world drugs consumption, in that, $H_t^{\xi,B} = \Xi_t \forall t$. Drugs' production also uses G_t^F amount of guns purchased from Country A. There is aggregate uncertainty in producing drugs in that, there is a probability q where new drugs are produced and a probability $1-q$ where there is zero production in each period t, despite the costs incurred. Specifically, the expected payoff of the drugs syndicate is given by:

$$E(v_t^{\xi}) = \begin{cases} qP_t^{\xi}\xi_t - w_t^{\xi,B} H_t^{\xi,B} L_t^{\xi,B} - P_t^G G_t^F & \text{if } q \\ -w_t^{\xi,B} L_t^{\xi,B} - P_t^G G_t^F & \text{if } 1-q \end{cases}, \tag{42}$$

Combining (41) and (42), the problem of the drug syndicate is

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

by choosing raw labor hours, $L_t^{\xi,B}$ (it has no control over the economy-wide drug-specific human capital, which is akin to a type of cultural capital), and number of guns, G_t^F, yielding first-order conditions of:

$$\varphi q P_t^{\xi} \xi_t = w_t^{\xi,B} H_t^{\xi,B} L_t^{\xi,B}, \tag{43}$$

$$qP_t^{\xi}(1-\varphi)\xi_t = P_t^G G_t^F \tag{44}$$

Given that $H_t^{\xi,B} = \Xi_t \forall t$, equating (43) and (44), we have:

$$\frac{\varphi}{(1-\varphi)} = \frac{w_t^{\xi,B} H_t^{\xi,B} L_t^{\xi,B}}{P_t^G G_t^F}. \tag{45}$$

Drug distribution: The distribution of drugs produced in Country B to households in Country A are assumed to be costly. Specifically, adopting a specification that is commonly used in models with costly distribution (Burstein et al. 2003; Agénor 2016), distributing/smuggling a unit of drug requires using κ_t units of Country B-produced ordinary tradables traded to Country A ($C_t^{Dist} = \kappa_t C_t^{A,B}$). The existence of the distribution cost means that, in terms of the respective market price, there is a wedge between the market price of drugs and ordinary tradables, as in:

$$P_t^{\xi} = (1 + \kappa_t) P_t^T, \tag{46}$$

where $\kappa_t = \kappa_0 (\frac{\xi_t}{\Xi_t})^{-\rho}$. This means the larger the quantity of current drugs production is, the lower the spread between drug price and ordinary tradable good. The larger the past accumulated drugs consumed (in other words, the more established world drugs trade is), the higher the price mark-up of drugs.

Rewriting (46), we can express the price ratio of drugs and tradables as:

$$\frac{P_t^{\xi}}{P_t^T} = [1 + \kappa_0 (\frac{\xi_t}{\Xi_t})^{-\rho}]. \tag{47}$$

2.3 Market-clearing conditions

In **Country A**, the equilibrium conditions of the factor markets for physical capital and labor are given by $K_t = K_t^A$, and $L_t = L_t^{T,A}$. For the ordinary tradable goods produced in Country A, equating supply to demand, which consists of private consumption by households in Country A, investment, government consumption, inputs used in guns-production, and those traded to Country B ($C_t^{B,A}$), we have

$$Y_t^{T,A} = C_t^{A,A} + I_t + G_t^A + Y_t^{T,AG} + C_t^{B,A}. \tag{48}$$

For **Country B**, we first impose the *symmetric equilibrium* assumption, where all individuals are identical. This means, for all individuals $j \in (0, 1)$, $C_{j,t}^B = C_t^B$, $C_{j,t}^{B,B} =$

$C_t^{B,B}$, $C_{j,t}^{B,A} = C_t^{B,A}$, $L_{j,t}^{T,B} = L_t^{T,B}$, $L_{j,t}^{\xi,B} = L_t^{\xi,B}$. All individual and aggregate behaviors are consistent, and by implication of the identical human capital investment decisions, all individual-specific human capital equal the economy-wide average level of human capital, that is, $H_{j,t}^{\xi,B} = H_t^{\xi,B}$, $H_{j,t}^{T,B} = H_t^{T,B}$. On aggregate, $L_t^{\xi,B} + L_t^{T,B} = 1$ holds due to symmetry.

For the ordinary tradables produced in Country B, the supply, $Y_t^{T,B}$, equals the demand, which consists of private consumption by households in Country B, those traded to Country A ($C_t^{A,B}$), and those used in distributing drugs to Country A:

$$Y_t^{T,B} = C_t^{B,B} + C_t^{A,B} + C_t^{Dist}.$$

Given that $C_t^{Dist} = \kappa_t C_t^{A,B}$, we have

$$Y_t^{T,B} = C_t^{B,B} + (1+\kappa_t) C_t^{A,B}. \tag{49}$$

There is free international trade between the two countries for the ordinary tradables. Therefore, the ordinary tradable goods prices are equalised across the two countries at P_t^T in each period t. However, note that factor prices are not equalised, given the different production structures of the two countries are different.

The international market equilibrium for guns are given by

$$Y_t^{G,A} = G_t^G + G_t^F. \tag{50}$$

3 Balanced growth equilibrium and solutions

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 *dynamic international trade equilibrium* in which, by implications of free trade, both Country A and Country B grow at a constant rate. For a given set of parameters, this means **(i)** the endogenous variables $(C_t^A, C_t^{A,A}, C_t^{A,B}, \xi_t, C_t^B, C_t^{B,B}, C_t^{B,A}, K_t^A, H_{j,t}^{\xi,B}, H_{j,t}^{T,B}, \Xi_t, Y_t^{T,A}, Y_t^{T,B}, Y_t^{G,A})$ all grow at a constant, endogenous rate $\boldsymbol{\gamma}$, with the levels exhibit steady-state properties. This implies that **(ii)** the current-to-accumulated drug consumption ratio $(\Phi_t^{\xi\Xi} = \xi_t/\Xi_t)$, ordinary tradable-drugs consumption ratio of Household in Country A $(\Phi_t^{C_A\xi} = C_t^A/\xi_t)$, ordinary tradable output-to-physical capital ratio in Country A $(\Phi_t^{Y_{TA}K_A} = Y_t^{T,A}/K_t^A)$, Country A's tradable consumption-to-physical capital ratio $(\Phi_t^{C_AK_A} = C_t^A/K_t^A)$, Country A-Government's purchased guns-to-physical capital ratio $(\Phi_t^{G_GK_A} = G_t^G/K_t^A)$, Country A's exported guns-to-physical capital ratio $(\Phi_t^{G_FK_A} = G_t^F/K_t^A)$, ordinary tradable output of Country B-to-physical capital in Country A ratio $(\Phi_t^{Y_{TB}K_A} = Y_t^{T,B}/K_t^A)$, Country B's ordinary tradable output-to-formal human capital ratio $(\Phi_t^{Y_{TB}H_B} = Y_t^{T,B}/H_t^{T,B})$, the two countries' relative key factor inputs' ratio $(\Phi_t^{H_BK_A} = H_t^{T,B}/K_t^A)$, Country B's household consumption-to-Country A's physical capital ratio $(\Phi_t^{C_BK_A} = C_t^B/K_t^A)$, and the ordinary tradable output-to-drugs produced ratio in Country B $(\Phi_t^{Y_{TB}\xi} = Y_t^{T,B}/\xi_t)$ are all constant $\forall t$; **(iii)** factor returns, wages, and prices are constant, and by implications, **(iv)** the drugs-ordinary tradable market price ratio (P_t^{ξ}/P_t^T) and the guns-ordinary tradable market price ratio (P_t^G/P_t^T) are also constant.

The dynamic system characterizing the solutions is solved for and summarized in the end of Appendix A. We first study the solutions under the *balanced growth equilibrium* (BGE), characterized by the set of simultaneous equations solved for in Appendix B, with the relevant steady-state variables denoted in tildes. For simplicity, we set the ordinary tradable price to be the base price, $\tilde{P}^T = 1$. Also, given that, by definition, the BGE means the growth rates are balanced across Country A, Country B, and drugs, we further supplement the analysis by examining (computationally) the transition dynamics of policies using the dynamic system presented in Appendix A, of which then the respective growth rate of Country A, Country B, and drugs can differ and driven by the equations, K_{t+1}^A/K_t^A, $H_{t+1}^{T,B}/H_t^{T,B}$, and ξ_{t+1}/ξ_t [(82)-(84) in Appendix A]. Given the complexity of the system, stability of the economy cannot be studied analytically. However, it is established numerically (based on the parameterization discussed next) by solving for an initial BGE that satisfies the properties defined earlier and verifying that following a shock, the system converges to a new BGE in a finite number of periods.

4 Benchmark Parameterization

For an illustrative representation of the model, we calibrate the parameters of Country A so as to match the endogenous ratios along the BGE to the first moment of the respective annual series for the United States (U.S.) in the 1990-2015 period. For drugs, as a self-containing measure, we focus only on the plant-based drugs of cocaine and cannabis. For Country B, to match the BGE characterization, the parameterization is based on the average value of the 5 economies of El Salvador, Guatemala, Honduras, Jamaica, and Mexico. All 5 economies: (i) are well-documented in the various publications of *United Nations Office on Drugs and Crime* [for instance, UNODC (2015-18)] to be major illicit cocaine or cannabis suppliers to the U.S., (ii) have formal trade sector that significantly depends on the U.S.; (iii) are controversially known for drug syndicates that involve in illicit drugs and guns trades on the American soil. On average, the real GDP growth rate of the 5 economies is slightly above 2.5 percent during the 1990-2015 period, therefore allowing for the setting of balanced growth rate of $\boldsymbol{\gamma} = 0.025$ to match that of Country A.

Given the annual time frequency and subsequent parameterizations, the discount factor is set at $\Lambda = 0.995$, which corresponds to an annual net return on physical capital of 4.5 percent. For Country A Household's utility function, the labor preference parameter, η_L, and the intertemporal elasticity of substitution for ordinary tradables, ς_{CA}, are set according to Smets and Wouters (2007) at 2.0 and 0.667 (which corresponds to 1.5 in their utility specification). The inverse of Frisch elasticity of labor supply is set at a fairly standard value of 8.0 (Agénor 2016). For the parameters related to rational addiction of drugs, from (9), it can be seen that the price elasticity of drugs consumption is approximated in the model by $-\varsigma_{\Xi}$. The elasticity of intertemporal substitution of drugs, ς_{Ξ}, is set at 0.46, which is the value estimated by Grossman (2004) and within the estimated range of Pacula et al. (2001). Similarly, as a simple rearranging of the same equation shows that the elasticity of period-t drug consumption with respect to past accumulated addiction is given by $\eta_{\Xi}(\varsigma_{\Xi} - 1)$. Based on the -0.27 estimate of Dave (2008) for chronic cocaine addiction, and using $\varsigma_{\Xi} = 0.46$, we set the preference parameter for accumulated addiction, $\eta_{\Xi} = 0.5$. For the rate of (anti-)persistency, ϕ, the empirically documented estimates for cigarettes addiction by studies such as Gruber and Köszegi (2001) are within the $0.5 - 0.9$ range. We set $\phi = 0.5$ to reflect the more addictive nature of drugs consumption. From (85), $\tilde{\Phi}^{\xi\Xi} = \phi + \boldsymbol{\gamma}$, which means the steady-state current-to-accumulated drug consumption ratio equals 0.525.

For the probability of avoiding confiscation of drugs, π, which can be interpreted as a proxy for drug liberalization, we set $\pi = 0.5$ in the absence of such an existing empirical estimate. Next, using the Bureau of Economic Analysis (BEA) statistics, the sum of imported consumer goods, food, and automotive divided by personal consumption expenditures on goods, gives an average of 0.145. From (12), this means $\theta = 1 - 0.145 = 0.855$.

For ordinary tradable production in Country A, the elasticity value with respect to effective labor, β, is set at 0.64, which is the common value used for United States in studies such as Christiano et al. (2005). Given the assumption $\beta = \varpi_T$, this means the strength of the Arrow-Romer externality with regards to physical capital stock is also 0.64. For the elasticity of labor productivity with respect to drugs consumption, we opt for a negative effect for the benchmark case by setting $\upsilon_A = -0.018$.[9] Next, based on the International Monetary Fund (IMF) capital stock dataset, the average final output-to-physical capital ratio of the United States is approximately 0.679, which is set as the value of $\tilde{\Phi}^{Y_{TA}K_A}$ along the balanced growth path. Likewise, applying the household consumption share as a percentage of GDP series from the BEA to the IMF capital stock dataset, we calculate Country A's tradable consumption-to-physical capital ratio in the BGE, $\tilde{\Phi}^{C_A K_A} = 0.453$. From (15),using also the employment and wage data from the BEA, $A_t^{T,A} = \frac{\beta(Y_t^{T,A}/L_t^{T,A})}{w_t^{T,A}} = 14.76$ is calculated. From (18), this means $A_0^A = 14.59$. After that, using (19), given all the other parameterization, the productivity parameter, $Q_0^{T,A} = 0.1213$ is estimated. Given these calibrations, and using the first-order conditions for $\tilde{r}^{T,A}$ and (87), we determine the physica capital depreciation rate, δ^K, at a relatively high rate of 0.2, so as to give an annual net (of depreciation) return on physical capital of 4.5 percent.

For guns, we rely on the various editions of the annual statistical update on firearms production and sales published by the Bureau of Alcohol, Tobacco, Firearms and Explosives, United States (ATF) for the parameterization. In the period of 1990-2015, 6.2 percent of total guns manufactured in the United States are exported, which gives us the ratio of $\tilde{G}^F$ over $\tilde{Y}^{G,A}$, and indirectly, its share against those purchased by the govern-

[9] The value corresponds to North America's annual prevalence rate of drugs consumption (UNODC, 2018). This means the parameterization strategy involves implicitly assuming that the prevalence of drug usage in the population translates to an equivalent effect on the aggregate labor productivity.

ment in Country A, $\tilde{G}^G$. For the tax rate on guns production, τ_G, based on the total tax revenues collected under the National Firearms Act (occupational tax plus transfer & making tax) and the estimated revenue of the guns and ammunition industry [see Brauer (2013) and various reported figures by the Firearms Industry Trade Association (NSSF)], $\tau_G = 0.003$ is estimated. For the production parameters, in the absence of existing estimates, the time-invariant shift parameter, A_0^G, is set at one. Further, a very low elasticity of guns' production with respect to tradable inputs is set at $\varkappa = 0.05$, which given the assumption $\omega = 1 - \varkappa = 0.95$, means guns production benefits immensely from knowledge spillover associated with the economywide physical capital stock—a reasonable feature consistent with anecdotal evidence.

For the Government in Country A, the labor and physical capital income tax rates are calibrated based on the average wage income tax rate faced by a childless single person at 100% of average earnings (as estimated by the OECD) and the statutory corporate income tax rate, yielding $\tau_L = 0.174$ and $\tau_K = 0.350$ respectively. The share of government consumption as a percentage of the domestically produced tradables is estimated using the BEA statistics again, which gives $\nu = 0.340$. Lastly, the fraction of realizable value from confiscated drugs is set at a very low rate of 0.1.

For the preference parameters in Country B, for consistency and due to a general lack of country-specific macroeconomic studies for the sample economies, the same values for the intertemporal elasticity of substitution, the inverse value of Frisch elasticity, and the labor preference parameter are used, where $\varsigma_{CB} = 0.667$, $\psi_B = 8.0$, and $\eta_B = 2.0$. The share of domestically produced ordinary tradables for households in Country B is set at $\varrho = 0.8$, which is in line with the averages of the sample economies. For the remaining parameters, following Mocan et al. (2005), the formal/legal human capital depreciation rate is set at 0.05, while the parameter for the efficiency of formal/legal human capital investment, Θ_{HB}, is set at 0.156. Together, these yield steady-state human capital investment (δ^{HB}/Θ_{HB}) that approximates the average expenditure per student in tertiary education (32 percent of GDP per capita) for the five sample economies. Given that our stylized model does not separately model drugs farming, processing, and trafficking in distinct details, the share of labor hours allocated to drugs production, $1-\vartheta = 0.15$, is set in accordance to the usual estimates of employment/time spent in coca farming by the Andean farmers [see Angrist and Kugler (2008), Organization of American States (2013), and the various annual reports of UNODC].

For ordinary tradable production in Country B, the production elasticity, α, is set at 0.6, which is in line with the average estimated labor share of Guerriero (2012) for the 5 economies. Given that $\phi_1 = 1-\alpha$ must hold to generate endogenous growth in Country B, the learning externality is set at 0.4, which is in consistent with studies such as Agénor (2016). For the shift parameter, $Q_0^B = 9.41$, its value is derived residually from the relative human capital (or relative wage) ratio along the BGE, derived in (85) to be $\tilde{H}^{T,B}/\tilde{H}^{\xi,B} = \tilde{w}^{\xi,B}/\tilde{w}^{\xi,B} = [\varphi q\vartheta(1+\tilde{\kappa})(\phi+\boldsymbol{\gamma})]/[(1-\vartheta)\alpha Q_0^B Q_0^{T,A}(A_0^A)^{\beta}(\phi+\boldsymbol{\gamma})^{\upsilon_A\beta}\vartheta^{\alpha}]$, the value of which in turn depends on the parameterization for the drugs sector.

For the drugs sector, the initial value of the relative human capital ratio, $\tilde{H}^{T,B}/\tilde{H}^{\xi,B}$, is set at 0.25 to reflect a relatively low formal human capital in relation to drug-specific human capital. This, given an intial $\tilde{w}^{\xi,B} = 1$, yields $\tilde{w}^{T,B} = 4$. With $\tilde{P}^T = 1$, the steady-state drug price, $\tilde{P}^{\xi}$, is parameterized based on the average wholesale price of cocaine base (USD'000 per kg) in 3 of the sample economies with data (Jamaica: USD 5.795, Guatemala: USD 9.329, Honduras: USD7.3), yielding $\tilde{P}^{\xi} = 7.5$. This then gives $\tilde{\kappa} = 6.5$. In the absence of reliable statistics, and given that it is a policy arrangement that will be evaluated extensively in our policy experiments, we set the initial benchmark probability of successfully producing drugs at $q = 0.5$. Given the values of $\tilde{w}^{\xi,B}$, $\tilde{\Phi}^{\xi\Xi}$, q, and $\tilde{L}^{\xi,B}$, using (43), we can estimate the elasticity of drugs production with respect to drug-specific effective labor, φ, to be 0.076. Lastly, given a value of $\rho = 0.05$, the shift parameter for distribution cost, κ_0, equals 6.294.

The remaining variables are calibrated as follows. With all the parameters determined, we can calculate the steady-state value of ordinary tradable consumption in Country B and A using (91) and (101) respectively, yielding unadjusted values of $\tilde{C}^B = 0.516$ and $\tilde{C}^A = 1.296$. Given that $\tilde{\Phi}^{C_A K_A} = 0.453$, we can then determine the unadjusted benchmark value for $\tilde{K}^A$.[10] For the steady-state price of guns, $\tilde{P}^G$, we first estimate a price ratio of $\tilde{P}^\xi / \tilde{P}^G$. While precise sales estimates for both drugs and guns are impossible to pin down, we can derive a price ratio based on the respective quantity of production, as well as the estimated total industry values (NSSF and ATF for guns, UNOCD for drugs). We estimated $\tilde{P}^\xi / \tilde{P}^G = 1.82$, which gives $\tilde{P}^G = 4.12$. From (44), we also calculate $\tilde{P}^G \tilde{G}^F = 1.878$, which then gives $\tilde{G}^F = 0.456$. Country A's exported guns-to-physical capital ratio along the BGE is then estimated to be $\tilde{\Phi}^{G_F K_A} = 0.159$. To ensure the parameterization is realistic, using (108) from Appendix B, and both $\tilde{\Phi}^{C_A K_A}$ and $\tilde{\Phi}^{G_F K_A}$, we get a guns-to-consumption ratio in Country A of 0.35, a value that approximates the proportion of American households with firearms (Smith and Son 2015). From (107) in Appendix B, $\tilde{\Phi}^{C_A K_A} = \left\{ A_0^R \pi^{-\varsigma_{CA}} (\phi + \boldsymbol{\gamma})^{\frac{\varsigma_{CA}}{\varsigma_\Xi} - \varphi} (1 - \vartheta)^\varphi (1 + \tilde{\kappa})^{\varsigma_{CA} - \varphi} (\tilde{P}^G)^\varphi \left[q(1 - \varphi) \right]^{-\varphi} \right\} \tilde{\Phi}^{G_F K_A}$, which then allows us to derive the last parameter value, $A_0^R = 1.291$. In sum, all the parameter values are summarized in Table 1 and 2.

5 Illustrative Policy Experiments

In the policy debate on modern drug control (LSE, 2014), a key controversy often surrounds the question of whether it is most effective for intervention to be in the final consumer stage (also, *prohibition* vs. *legalization*), the initial production stage (*interdiction* policy at source country), or in the intermediate trafficking/transhipment stage. In

[10] As shown in Appendix B, in order for the existence of non-cornered solution for $\tilde{C}^B > 0$, the parameterization must satisfy the analytical conditions, $\Lambda^{-1}(1 + \boldsymbol{\gamma})^{\varsigma_{CB}^{-1}} - (1 - \delta^{HB}) > 0$, which is indeed the case for our benchmark. In addition, it is also common practice, when implementing numerical policy experiments for transition dynamic analysis in the later section, to normalize the initial values of $\tilde{K}^A$, $\tilde{C}^B$, and $\tilde{C}^A$ from the unadjusted value to an index of one. These have no effect on the computations of the gross growth rates of the aforementioned variables.

addition, there are also concerns about the impact of the illicit gun trade on drugs trades (and related conflicts). Given the rigorous (albeit stylized) analytical foundations of our model, we set out to answer some of these questions by implementing numerical policy experiments using the parameterized model. We consider four individual policies: (i) an increase in the probability of not having drugs confiscated by the government in Country A, π (a proxy for relaxed legislation); (ii) a decrease in the probability of successfully producing drugs by the drug syndicate in Country B, q (more prohibitive supply-side policy); (iii) an increase in the shift parameter for drug distribution, κ_0, so as to make drug transhipment more costly; and (iv) an increase in the tax rate for guns production, τ_G.[11] For consistency of comparison, all simulated policy experiments involve a permanent one percent shock from the initial parameter values set for the respective parameters.

5.1 Is *legalization* or *prohibition* the better approach?

To examine this question, we simulate a permanent one percent increase in the probability of not having drug confiscated by the government in Country A, π. This can be interpreted as a growing relaxation of drug control policy at the final consumer market, hence a proxy for potential legalization of drug possession. The steady-state effects are summarized in Table 3, with the transition dynamics of selected variables illustrated in Figure 1. In the benchmark case, both current-period drug consumption/production ($\tilde{\xi}$) and its size relative to accumulated stock of addiction ($\tilde{\Phi}^{\xi\Xi}$) increase by 0.44 and 0.52 percent respectively in the steady state. For Country A, this translates to the growth rate of physical capital stock, and by implication the growth rate of tradable output over the

[11] It is worth pointing out that, to save space, a policy experiment with regards to human capital investment efficiency in Country B, Θ_{HB}, is not presented. As would be seen, all 4 drug-control related polices considered have only *level* and not *growth* effect on Country B's ordinary tradable production in the steady state. A permanent increase in Θ_{HB} is the obvious policy to raise the growth rate of tradables in Country B (for instance, doubling Θ_{HB} will raise steady-state growth rate of $Y^{T,B}$ by 1.1 percent). However, the policy largely has no steady-state effect on the growth rates of key variables in Country A, as well as the drugs and guns trades, therefore not being explicitly discussed.

long run (given the constancy of $\tilde{\Phi}^{Y_T{}_A K_A}$), declining by 1.0 percent. However, given the constancy of private household consumption allocation between ordinary tradables and drugs in Country A in the long run ($\tilde{\Phi}^{C_A \xi}$), growth rate of private consumption increases at 0.44 percent too. For Country B, by implication of the productivity specification in (38), the growth rate of tradable output in Country B is largely unaffected in the long run (as it depends on the ratio $\tilde{\Phi}^{Y_T{}_A K_A}$). However, as seen in Figure 1, there is a negative impact effect on ordinary tradable production in Country B. This is due to the increase in drug consumption relative to accumulated addiction, which means the accumulated drug-specific human capital stock is increasing over time along the transition path. At the optimality condition for individuals in Country B ($\tilde{H}^{T,B}\tilde{w}^{T,B} = \tilde{H}^{\xi,B}\tilde{w}^{\xi,B}$), at a given relative wage ratio, the rise in the level of $\tilde{H}^{\xi,B}$ also means a decline in the level of formal/legal human capital stock $\tilde{H}^{T,B}$, resulting in a decline of the growth rate of relative human capital stock in Country B. Formal tradable production in Country B therefore declines in level, despite the policy being growth-neutral for Country B in the long-run. Consequently, this translates to lower private consumption of tradables in Country B, which in turn has a negative effect on the ordinary tradable production in Country A. The decline in the growth rate of both $\tilde{Y}^{T,A}$ and $\tilde{K}^{A}$ leads to a decline in the growth rate of guns production, given that its production uses the former as input while benefits from the spillover effect of the latter.

While not explicitly presented, it is worth noting that the simulation results with respect to a change in π are largely monotonic, in that, an opposite experiment of a tougher drug legislation (decline in π) delivers the opposite effects (albeit at slightly different magnitude) for all the key variables. In addition, as seen in the sensitivity results presented, the policy effects are mostly robust to key parameter changes, including *both* positive and negative elasticities with regards to labor productivity in Country A. In other words, irresspective of whether drug consumption improves or reduces labor productivity in Country A, the policy effects associated with a change in π are consistent. However, interestingly, as would also be seen in all the other experiments, a smaller initial value of the intertemporal elasticity substitution for drugs consumption, ς_{Ξ}, would result in increased cyclicality in the model behaviors. While the long-run steady-state effects, in terms of signs/policy directions, are still consistent with the benchmark case (albeit at stronger magnitudes), the cyclicality means any drug policy targeted at the final consumer stage will have less predictable transition path the lower the intertemporal elasticity of substitution is.

"*Is legalization or prohibition the better approach?*" Based on the analysis, stricter drug control policy is growth-enhancing in the long run and promotes formal/legal human capital accumulation in the source country, though households in Country A will experience a decline in consumption growth. If the maximization of private consumption growth (often a welfare indicator) is is the leading objective over production growth-maximization, then there is a rationale for Country A to relax its drug-control rule at the cost of some deceleration in tradable output growth.

5.2 Does more interdiction & prohibitive supply-side policy work?

Next, we consider policy targeting directly the supply-side, which includes measures that attempt to eradicate drug cultivation. Such policies can be proxied by a permanent decrease in the probability of successfully producing drug in Country B. We simulate a one-percent decrease in q from the initial probability, with results on the steady-state effects and transitional dynamics presented in Table 3 and Figure 2 respectively. This has a direct negative impact on drugs production, resulting in an immediate impact of -0.80 percent on growth of current-period drug production, and eventually a stable steady-state effect of -0.67 percent. As a share of accumulated stock of addiction, the ratio declines by 0.78 percent. This translates to a decline in the stock of drug-specific human capital, which for a given relative wage ratio, means an increase in the *level* of formal/legal human capital stock in Country B. This in turn leads to a higher *level* of ordinary tradable production in Country B. While the steady-state effect on growth rate remains muted given the (38) specification, the expansion in production level means there is a short-term positive effects on the growth rate of tradable production in Country B along the transition path, as seen in all-but-one cases in Figure 2 (except when $\upsilon_A = 0.072$, in which drug consumption has a positive *stimulant* effect on labor productivity in Country A).

In the steady state, the decline in drugs production, at a given demand and consumption allocation of household in Country A, leads to a decline in overall growth rate of private consumption in Country A. However, the steady-state gains in the *level* of ordinary tradables and the *growth* of relative human capital stock in Country B lead to higher *level* of trades between the 2 countries, resulting in a long-run increase in tradable production in Country A by 4.8 percent. At a given tradable output-to-physical capital ratio, this means growth rate of physical capital stock also rises by 4.8 percent. By implication, steady-state growth rate of private consumption in Country B increases by the same magnitude. Lastly, the steady-state increase in the price of drugs (due to the decline in supply) means, at a given equilibrium drug-gun price ratio, the price of guns declines (by 2.9 percent), resulting in a steady-state increase of total guns production.

In terms of the sensitivity analysis results, the long-run policy effects appear to be robust across most parameters, though increased cyclicality along the transition path is observed again when $\varsigma_{\Xi} = 0.3$. In addition, when the demand of tradable inputs in guns production is a lot more elastic ($\chi = 0.5$), the steady-state expansionary growth effects observed for tradable production and physical capital in Country A, and private consumption in Country B are reversed. In this instance, the contractionary effect in guns production (associated with the decline in drug supplies) weights more heavily on tradable production in Country A, and this negativity dominates the *international trade-expansionary* effect associated with higher level of tradable production in Country B. In summary, our simulation results show that more prohibitive supply-side intervention appears to be effective in reducing world drug supplies while promoting growth in ordinary tradable good trades. More significantly, there is again a *production-consumption growth trade-off* observed in Country A for all but one of the cases examined.

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

It is often perceived that growing interdiction of transhipments in the recent decades had successfully elevated drug prices to a very high level at the final wholesale and retail levels, which in turn significantly reduced global drug consumption. *Is this a universally good policy?* We address this question by simulating a permanent one-percent increase in the distribution cost parameter, κ_0. The steady-state effects are summarized in Table 4, and the transition dynamics of key variables illustrated in Figure 3. Predictably, the steady-state drug price increases by 6.7 percent, and this leads to declines in both steady-state supply and demand. Nevertheless, given that the benchmark parameterization is one that portrays relative inelastic drug supply and demand, current-period drug production declines by only 0.16 percent in the long run. In terms of its consumption relative to accumulated stock of addiction, the ratio is about 0.2 percent lower in the new steady state. At a given consumption allocation, household in Country A experiences a decline in private consumption growth.

For Country B, the decline in accumulated stock of drug-specific human capital means, at a given relative wage ratio, the *level* of formal/legal human capital stock increases, leading to a permanent increase in the growth rate of relative human capital stock. This in turn leads to an expansion in the *level* of ordinary tradable production in Country B. Nevertheless, given the positive *level*, but not *growth*, effect on formal human capital, the positive effect on tradable production growth in Country B is only along the transition path. At the same time, the decline in drugs production also leads to a steady-state drop in the demand of the input of guns, the production of which uses ordinary tradables in Country A. Unlike the two previously considered experiments, for this specific policy, the combination of this and the decline in private consumption growth in Country A dominates the initial *international trade-expansion* effect even in the benchmark case, causing the growth rate of ordinary tradable production in Country A to decline by 1.6 percent in the steady state. Physical capital stock declines by the same magnitude in the resulting steady state, and the declining tradable production growth in Country A leads to lower private consumption growth in Country B in the steady state. Lastly, the drop in gun supplies leads to the price of guns to increase, eventually restoring the drug-gun price ratio to a new equilibrium level. In short, the results show that, 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. The long-run steady-state effect is also small.

In terms of sensitivity analysis, notwithstanding the two established observations with transitional dynamics (lower ς_{Ξ}: increased cyclicality; positive υ_A: negative transitional effect of growth in tradable production in Country B), the results are largely consistent again with a single exception ($\chi = 0.5$). In this specific instance, the steady-state effects associated with tradable production and physical capital in Country A, and private consumption in Country B are reversed again. This suggests potential significance of the guns production structure in this model, and the structural significance of this parameter is examined in greater details later.

5.4 The controversial drug-gun trade nexus

A permanent one-percent increase in the tax rate on guns production, τ_G is simulated. The steady-state and transitional dynamic effects of selected variables are presented in Table 4 and Figure 4 respectively. Recall that our stylized model essentially treats all illicit component of world gun trades as the exported share, while the purchase made by the government in Country A can be interpreted as all other legal purchases. As such, while this experiment does not shed light on the heated domestic gun-control debate that has been taking place in the United States recently, it does refer to a taxation/fee that is levied on the production of all guns.

In Table 4, it is seen that the tax rate is growth-neutral on drugs production in the long run, despite guns being modelled as a factor of production for drugs. Given this, the long-run effect on current-to-accumulated drug consumption ratio is also muted, therefore leading to growth neutrality in the relative human capital stock in Country B too. At a given ordinary tradable-drugs consumption ratio, the long-run growth neutrality of $\tilde{\xi}$ means the growth effect of private consumption of tradables in Country A is also muted. Nevertheless, along the transition path, it is clearly seen in Figure 4 that there are short-run effects along the transition path, with the model taking a much longer time to transit to the new steady state compared to the 3 experiments previously considered.[12] The higher tax levied at production leads to an instantaneous decline in the supply of guns. At the initial factor-price ratio for guns production, this negative supply shock leads to a decrease in drugs production on impact and by implication, the growth rate of drug-specific human capital. At a given initial level of relative stock of human capital, this translates to an increase in the growth rate of relative human capital stock in Country B along the transition. However, the decline in current-period drug production means drug price increases on impact, leading to a decline in drug consumption. At an initial optimal consumption allocation, household in Country A consumes less on impact, leading to a decline in the growth rate of ordinary tradable production in Country B on impact. Nevertheless, given that the optimality condition for drugs production remains unchanged, the actual world price of guns remains unchanged. From the optimality condition in (24),

[12] Indeed, for the sensitivity analysis with regards to lower ς_{Ξ}, the growing cyclicality is such that, the system runs into convergence issue for parameterization with $\varsigma_{\Xi} < 0.43$. We present the case where $\varsigma_{\Xi} = 0.44$ in Figure 4, which shows that the variables still do not converge to the new steady state after $T = 200$.

the guns manufacturer eventually makes up for this production levy by producing more guns (+0.5 percent at the steady state) and in the process, demands more tradable inputs. This translates to a steady-state increase of the same magnitude for the growth of tradable production and physical capital stock in Country B, and consequently via international trade, the growth of private consumption in Country B. As all the other production dynamics in Country B are unaffected by this policy in the long-run, growth neutrality is eventually observed for the growth rates of tradables, relative human capital stock, and drugs production in Country B as the economy coverges to the new steady state.

The experiment considered essentially shows that, any non-quota gun-control policy, such as a tax levied on production, will have no long-term implication on illicit guns trade, if there is no fundamental change to its demand and supply. This, together with the limited long-run growth effect observed with transhipment intervention, is consistent with the logic of the "*drug-producer compensates with increased higher productivity*" effect documented in Ortiz (2003, 2009), hence partly explains the limited effect of drug trafficking-control measures in the region (see, for instance, Reuter and Trautmann 2009).

5.5 Further sensitivity analysis

Based on the results of the individual policies considered, the long-run growth effects of the two major drug control policies are further evaluated in the context of varying trade openness in Table 5 and 6.

Specifically, in Table 5, the first policy experiment with regards to π is repeatedly simulated with different parameterization of the share of domestically produced tradables in the aggregate consumption of household in Country A, θ. In addition, given the well-documented significance of the (anti-)persistency rate, ϕ, in the rational addiction literature, we also evaluate the policy outcome across $\phi \in (0.1, 0.9)$. The initial value of ϕ is structurally significant in that, for any given value of θ, there is a range of value for ϕ where the steady-state growth effect of production in Country A is negative, when drug law is liberalized. Indeed, the more open Country A is (proxied by a larger share of imported goods in households' aggregate consumption of tradables, smaller θ), the narrower the range of ϕ with negative growth effect, hence providing greater possibility for drug liberalization policy to be growth-enhancing. Overall, despite a completely different framework, our findings are mainly consistent with Becker et al. (2006), in that, the more addictive drug is, the greater the increase in the social cost from using greater enforcement; the less past addiction influences current consumption, there is greater room for potential benefits in pursuing drug liberalization.

In Table 6, we assess the policy that is more relevant to Country B, which is the experiment of a permanent decrease in the probability of successfully producing drug, q, across a range of Country B' consumption share of domestically produced tradables (ϱ). Moreover, given the observed structural significance of the guns' production elasticity, χ, in the benchmark case, we also evaluate the policy effectiveness (in terms of private consumption growth in Country B) across different χ values. Unlike the previous case, a clear structural break-point for χ is observed for different ϱ values, below which the growth effect on consumption in Country B is positive. It appears that, the more "closed" Country B is (in terms of its individuals' consumption share), the lower the structural break-point for χ is. Given that the Arrow-Romer externality effect in guns production sector is given by $\omega = 1 - \varkappa$, this provides a natural policy interpretation. In essence, if Country B is more "closed" (higher ϱ value), in order for prohibitive supply-side policy to be growth-enhancing to household consumption in Country B, the learning externality or degree of knowledge spillover in the guns-production industry would need to be higher.

6 Concluding Remarks

Against the backdrop of a persistent, well-documented, yet controversial illicit drugs and firearms trade in the Central American and Caribbean region, this paper contributes to the literature by developing a two-country, multi-sectorial dynamic general equilibrium model of endogenous growth with drugs and guns trade. To date, the literature on macroeconomics of drugs have focused mainly in modelling the vertical supply-chain of drugs and the resulting conflicts from drug trafficking. We adopt a relatively horizontal perspective to model the world illicit trades, by developing a unified growth framework with international trade that also accounts for drugs' rational addiction in the demand side. This allows us to fill the 3 major gaps in existing analytical literature, namely: (i) examine the dynamic tradeoff and long-run growth implications of drug-control policies in *both* consuming and producing countries; (ii) explicitly model the firearm market—albeit in a stylized manner—and explore its link to the illicit drugs trade; (iii) analyze the spillover effects between illicit trades and formal international trades. The numerical policy experiments (using parameterized version of the model) help uncover a *output growth-consumption* tradeoff that is previously not documented in the literature, while providing some insights to a number of drug-control policy questions that are real and concrete (previewed in the Introduction and will not be repeated here).

Despite the contributions, there remain shortcomings that future studies can address. While we believe the model provides a better 'world-view' to the illicit trades, some features of vertically-integrated models, such as Mejía and Restrepo (2016), have to be dropped as self-contained measures to enable the existence of both analytical solutions of a BGE and numerical solutions for the large-scale dynamic system. Our model therefore is unable to account for phenomenon such as the 'balloon effect' (the ability of drug production to move to a new location or across international borders), and any resulting spike in violence and conflicts associated with drug trades. In addition, the modelling of drug-consumers, while accounted for rational addiction, has also omitted the possibility of asymmetric information and costly search, such as in Galenianos et al (2012). The same can be said for the illicit guns trade, which is modelled in a very simplistic manner. For future research, any attempt to "expand the universe" of the model will necessarily involve accounting for these features. In addition, with greater availability of data, given the notorious volatility in drug supply and prices, the introduction of more stochastic elements into a dynamic model to capture more realistic short-term movements in drug prices is also warranted.

References

Agénor, Pierre-Richard (2016). Optimal fiscal management of commodity price shocks. *Journal of Development Economics* 122(C), 183-96.

Alexeev, Michael, Janeba, Eckhard, and Stefan Osborne (2004). Taxation and evasion in the presence of extortion by organized crime. *Journal of Comparative Economics* 32(3), January, 375-87.

Angrist, Joshua, and Adriana D. Kugler (2008). Rural windfall or a new resource curse? Coca, income, and civil conflict in Colombia. *Review of Economics and Statistics* 90(2), May, 191-215.

Bagley, Bruce M. (2012). *Drug trafficking and organized crime in the Americas: Major Trends in the Twenty-First Century.* Woodrow Wilson Center Update on the Americas. Woodrow Wilson International Center for Scholars: Latin American Program. August, Washington, DC: Wilson Center.

Bagley, Bruce M., and Jonathan D. Rosen (2015). *Drug Trafficking, Organized Crime, And Violence in the Americas Today.* Gainesville: University Press of Florida.

Becker, Gary S., and Kevin M. Murphy (1988). A theory of rational addiction. *Journal of Political Economy* 96(4), 675-700.

Becker, Gary S., Grossman, Michael, and Kevin M. Murphy (2006). The market for illegal goods: The case of drugs. *Journal of Political Economy* 114(1), 38-60.

Blackburn, Keith, Neanidis, Kyriakos, and Maria Paola Rana (2017). A theory of organized crime, corruption and economic growth. *Economic Theory Bulletin* 5(2), 227-45.

Blumstein, Alfred (1995). Youth violence, guns, and the illicit-drug industry. *Journal of Criminal Law and Criminology* 86(1), 10-36.

Blumstein, Alfred, Rivara, Frederick P., and Richard Rosenfeld (2000). The rise and decline of homicide—and why. *Annual Review of Public Health* 21, May, 505-41.

Brauer, Jurgen (2013). The US firearms industry: Production and supply. Working Paper No. 14. Geneva, Switzerland: Small Arms Survey.

Bureau of Alcohol, Tobacco, Firearms and Explosives, United States (ATF-US) (2017). *Firearms commerce in the United States: Annual statistical update 2017.* United States Department of Justice.

Burstein, Ariel Thomas, Neves, Joao C., and Sergio T. Rebelo (2003). Distribution costs and real exchange rate dynamics during exchange-rate-based stabilizations. *Journal of Monetary Economics* 50(6), 1189-214.

Buxton, Julia (2015). *Drug Crop Production, Poverty, and Development.* New York, NY: Open Society Foundation.

Christiano, Lawrence J., Eichenbaum, Martin, and Charles Evans (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of Political Economy* 113(1), February, 1-45.

Dave, Dhaval (2008). Illicit drug use among arrestees, prices and policy. *Journal of Urban Economics* 63(2), 694–714.

Demombynes, Gabriel (2011). Drug trafficking and violence in Central America and beyond. Background Case Study for World Development Report 2011. Washington DC: World Bank.

Dills, Angela K., Miron, Jeffrey A., and Garrett Summers (2010). What do economists know about crime? In: *NBER Chapters: The Economics of Crime: Lessons for and from Latin America*. National Bureau of Economic Research, Inc., 269-302.

Galenianos, Manolis, Pacula, Rosalie L., and Nicola Persico (2012). A search-theoretic model for the retail market for illicit drugs. *Review of Economic Studies* 79(3), 1239-69.

Grossman, Herschel I., and Daniel Mejía (2008). The war against drug producers. *Economics of Governance* 9(1), 5-23.

Grossman, Michael (2004). Individual behaviors and substance use: the role of price. NBER Working Paper Number 10948, Cambridge, MA: National Bureau of Economic Research.

Gruber, Jonathan, and Botond Köszegi (2001). Is addiction rational? Theory and evidence. *Quarterly Journal of Economics* 116(4), 1261-303.

Guerriero, Marta (2012). The labour share of income around the world: Evidence from a panel dataset. Development Economics and Public Policy Working Paper No. 32, University of Manchester.

Imrohoroğlu, Ayse, Merlo, Antonio, and Rupert Peter (2004). What accounts for the decline in crime? *International Economic Review* 45(3), 707-29.

Imrohoroğlu, Ayse, Merlo, Antonio, and Rupert Peter (2006). Understanding the determinants of crime. *Journal of Economics and Finance* 30(2), 270-84.

Kilmer, Beau, Sohler Everingham, Susan, Caulkins, Jonathan P., Midgette, Greg, Pacula, Rosalie L., Reuter, Peter, Burns, Rachel M., Han, Bing, and Russell Lundberg (2014). *What America's users spend on illegal drugs: 2000-2010.* Santa Monica, California: RAND Corporation.

Kugler, Maurice, Verdier, Thierry, and Yves Zenou (2005). Organized crime, corruption and punishment. *Journal of Public Economics* 89(9-10), 1639-63.

Kuziemko, Ilyana, and Steven D. Levitt (2004). An empirical analysis of imprisoning drug offenders. *Journal of Public Economics* 88, 2043-66.

Langton, Jerry (2011). *Gangland: The Rise of the Mexican Drug Cartels from El Paso to Vancouver*. Canada: John Wiley & Sons.

Latin American Commission on Drugs and Democracy (2016). *Drugs & Democracy: Toward a paradigm shift*. Geneva, Switzerland: Global Commission on Drug Policy.

Levitt, Steven D., and Sudhir A. Venkatesh (2000). An economic analysis of a drug-selling gang's finances. *Quarterly Journal of Economics* 115(3), 755-89.

London School of Economics (LSE) (2014). *Ending the Drug Wars.* Report of the LSE Expert Group on the Economics of Drug Policy, May, London: LSE.

Mejía, Daniel, and Carlos Esteban Posada (2008). Cocaine production and trafficking: What do we know? Policy Research Working Paper No. 4618. Washington DC: The World Bank.

Mejía, Daniel, and Pascual Restrepo (2008). The war on illegal drug production and trafficking: An economic evaluation of Plan Colombia. Documento CEDE 19. Universidad de los Andes, CEDE.

Mejía, Daniel, and Pascual Restrepo (2016). The economics of the war on illegal drug production and trafficking. *Journal of Economic Behavior & Organization* 126, 255-75.

Miron, Jeffrey A. (2001). Violence, guns, and drugs: A cross-country analysis. *Journal of Law and Economics* 2(2), 615-34.

Mocan, H. Naci, Billups, Stephen, and Jody Overland (2005). A dynamic model of differential human capital and criminal activity. *Economica* 72(288), 655-81.
Organization of American States (OAS) (2013). The economics of drug trafficking, Chapter 4 in: *The Drug Problem in the Americas*. Washington DC: OAS.
Ortiz, Carlos H. (2003). La guerra contra las drogas es contraproducente: un análisis económico de equilibrio general. *Lecturas de Economía* 58, 47-68.
Ortiz, Carlos H. (2009). The war on drugs is counterproductive, once again. *Lecturas de Economía* 71, 19-42.
Pacula, Rosalie L., Grossman, Michael, Chaloupka, Frank J., O'Malley, Patrick, Johnston, Lloyd, and Matthew Farrelly (2001). Marijuana and youth. In: Jonathan Gruber (eds.), *Risky behavior among youths: An economic analysis*. Chicago, IL: University of Chicago Press, 93–191.
Pacula, Rosalie L., Kilmer, Beau, Grossman, Michael, and Frank J. Chaloupka (2010). Risks and prices: The role of user sanctions in marijuana markets. *B.E. Journal of Economic Analysis and Policy* 10(1), February, Art. 11.
Reuter, Peter (2008). Can production and trafficking of illicit drugs be reduced or merely shifted? Policy Research Working Paper No. 4564. Washington DC: The World Bank.
Reuter, Peter (2010). *Understanding the Demand for Illegal Drugs*. Washington, DC: National Academy Press.
Reuter, Peter, and Franz Trautmann (2009). *A Report on Global Illicit Drug Markets 1998-2007*. European Communities.
Rhodes, William, Johnston, Patrick, Han, Song, McMullen, Quentin, and Lynne Hozik (2002). *Illicit drugs: Price elasticity of demand and supply*. January, Cambridge, MA: Abt Associates.
Smets, Frank, and Rafael Wouters (2007). Shocks and frictions in US business cycles: A Bayesian DSGE approach. *American Economic Review* 97(3), June, 586-606.
Smith, Tom W., and Jaesok Son (2015). *General Social Survey: Trends in Gun Ownership in the United States, 1972-2014*. NORC at the University of Chicago.
United Nations Office on Drugs and Crime (UNODC) (2014). *World Drug Report 2014*. May, Vienna: United Nations publication.
UNODC (2015). *World Drug Report 2015*. May, Vienna: United Nations publication.
UNODC (2016). *World Drug Report 2016*. May, Vienna: United Nations publication.
UNODC (2017). *World Drug Report 2017*. May, Vienna: United Nations publication.
UNODC (2018). *World Drug Report 2018*. June, Vienna: United Nations publication
Whitford, Andrew B., and Jeff Yates (2009). *Presidential Rhetoric and the Public Agenda: Constructing the War on Drugs*. Baltimore, MD: Johns Hopkins University Press.

Table 1
Benchmark Parameter Values, Country A

Parameter	Description	Value
	Country A - Households	
Λ	Subjective discount factor	0.995
η_L	Preference parameter, disutility of labor	2.0
ψ	Inverse of Frisch elasticity of labor supply	8.0
ς_{CA}	Elasticity of intertemporal substitution, ordinary goods	0.667
π	Probability of avoiding confiscation, drugs possession	0.5
η_Ξ	Preference parameter, rational addiction	0.5
ϕ	Rate of (anti-)persistence, accumulated drugs consumed	0.5
θ	Share of domestically produced ordinary tradables	0.855
ς_Ξ	Elasticity of intertemporal substitution, drugs	0.46
δ^K	Physical capital depreciation	0.20
	Country A - Production	
β	Elasticity of ordinary tradables wrt effective labor	0.64
$Q_0^{T,A}$	Productivity parameter, ordinary tradables	0.1213
ϖ_T	Strength of Arrow-Romer externality, physical capital stock	0.64
υ_A	Elasticity of labor productivity wrt drugs consumption	-0.018
A_0^A	Productivity parameter, base labor productivity level	14.59
$\varkappa$	Elasticity of guns' production wrt tradable inputs	0.05
ω	Production externality from economywide physical capital stock	0.95
A_0^G	Time-invariant productivity parameter for guns' production	1.0
	Country A - Government	
ν	Share of gov. consumption in domestically produced tradables	0.340
τ_L	Labor income tax rate	0.174
τ_K	Physical capital income tax rate	0.350
τ_G	Taxation on guns' sales	0.003
z	Fraction of realizable value from confiscated drugs	0.100

Table 2
Benchmark Parameter Values, Country B

Parameter	Description	Value
	Country B - Individuals	
ς_{CB}	Elasticity of intertemporal substitution, ordinary goods	0.667
ψ_B	Inverse of Frisch elasticity of labor supply	8.0
η_B	Preference parameter, disutility of labor	2.0
Θ_{HB}	Parameter, efficiency of human capital investment	0.156
δ^{HB}	Formal/legal human capital depreciation rate	0.05
ϱ	Share of domestically produced ordinary tradables	0.8
ϑ	Share of labor hours allocated to ord. tradable production	0.85
	Country B - Production	
α	Elasticity of ordinary tradables wrt effective labor	0.6
Q_0^B	Productivity parameter, ordinary tradables	9.41
ϕ_1	Strength of Arrow-Romer externality, formal human capital	0.4
	Country B - Drug syndicate & distribution	
A_0^R	Productivity parameter, drugs production	1.291
φ	Elasticity of drugs production wrt drug-specific effective labor	0.076
q	Probability of successfully producing drugs	0.5
κ_0	Distribution cost parameter, drugs trade	6.294
ρ	Elasticity of distr. cost wrt current-to-accumulated world drugs trades	0.05

Table 3

Results Summary for Policy Experiments: Steady-state effects

(Absolute deviations from baseline)

An increase in the probability of not having drug confiscated by the government in Country A (π)

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

A decrease in the probability of successfully producing drug in Country B (q)

	Initial Values	Benchmark	ν_A = -0.072	ν_A = 0.072	ς_Ξ = 0.3	χ = 0.5	ρ = 0.5	β = 0.3
Growth of tradable output in Country A	0.025	**0.0479**	0.0488	0.0466	0.1114	-0.0246	0.0357	0.0498
Growth of private consumption, Country A	0.025	**-0.0066**	-0.0066	-0.0065	-0.0051	-0.0066	-0.0079	-0.0066
Growth of physical capital stock, Country A	0.025	**0.0479**	0.0488	0.0466	0.1115	-0.0246	0.0357	0.0498
Growth of tradable output in Country B	0.025	**0.0000**	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	0.0498
Growth of relative human capital stock, Country B	0.000	**0.0077**	0.0077	0.0077	0.0118	0.0077	0.0092	0.0077
Growth of current-period drug production	0.025	**-0.0066**	-0.0066	-0.0065	-0.0051	-0.0066	-0.0079	-0.0066
Current-to-accumulated drug consumption ratio	0.525	**-0.0077**	-0.0077	-0.0077	-0.0118	-0.0077	-0.0092	-0.0077
Price of drugs	7.500	**0.0048**	0.0048	0.0048	0.0074	0.0048	0.0579	0.0048
Growth of total guns production	0.025	**0.0479**	0.0488	0.0466	0.1114	-0.0246	0.0357	0.0498
Price of guns	4.120	**-0.0287**	-0.0287	-0.0287	-0.0252	-0.0287	-0.0032	-0.0287

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

Source: Authors' calculations.

Table 4

Results Summary for Policy Experiments: Steady-state effects (continue)

(Absolute deviations from baseline)

An increase in the price mark-up shift parameter for drug distribution (κ_0)

	Initial Values	Benchmark	ν_A = -0.072	ν_A = 0.072	ς_Ξ = 0.3	χ = 0.5	ρ = 0.5	β = 0.3
Growth of tradable output in Country A	0.025	**-0.0157**	-0.0155	-0.0160	-0.0176	0.0228	-0.0187	-0.0174
Growth of private consumption, Country A	0.025	**-0.0016**	-0.0016	-0.0016	-0.0007	-0.0016	-0.0019	-0.0016
Growth of physical capital stock, Country A	0.025	**-0.0157**	-0.0155	-0.0160	-0.0176	0.0228	-0.0187	-0.0174
Growth of tradable output in Country B	0.025	**0.0000**	0.0000	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	-0.0187	-0.0174
Growth of relative human capital stock, Country B	0.000	**0.0019**	0.0019	0.0019	0.0016	0.0019	0.0023	0.0019
Growth of current-period drug production	0.025	**-0.0016**	-0.0016	-0.0016	-0.0007	-0.0016	-0.0019	-0.0016
Current-to-accumulated drug consumption ratio	0.525	**-0.0019**	-0.0019	-0.0019	-0.0016	-0.0019	-0.0023	-0.0019
Price of drugs	7.500	**0.0662**	0.0662	0.0662	0.0660	0.0662	0.0792	0.0662
Growth of total guns production	0.025	**-0.0157**	-0.0155	-0.0160	-0.0176	0.0228	-0.0187	-0.0174
Price of guns	4.120	**0.0321**	0.0321	0.0321	0.0319	0.0321	0.0384	0.0321

An increase in the tax rate on guns sales (τ_G)

	Initial Values	Benchmark	ν_A = -0.072	ν_A = 0.072	ς_Ξ = 0.44*	χ = 0.5	ρ = 0.5	α = 0.3
Growth of tradable output in Country A	0.025	**0.0048**	0.0047	0.0047	0.0045	0.0001	0.0047	0.0068
Growth of private consumption, Country A	0.025	**0.0000**	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Growth of physical capital stock, Country A	0.025	**0.0048**	0.0047	0.0047	0.0046	0.0001	0.0047	0.0068
Growth of tradable output in Country B	0.025	**0.0000**	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Growth of private consumption, Country B	0.025	**0.0048**	0.0047	0.0047	0.0045	0.0001	0.0047	0.0068
Growth of relative human capital stock, Country B	0.000	**0.0000**	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Growth of current-period drug production	0.025	**0.0000**	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Current-to-accumulated drug consumption ratio	0.525	**0.0000**	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Price of drugs	7.500	**0.0000**	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Growth of total guns production	0.025	**0.0048**	0.0047	0.0047	0.0045	0.0001	0.0047	0.0068
Price of guns	4.120	**0.0000**	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note: All simulated policies represent a one percent shock from the initial value of the relevant policy arrangement.
* Numerical solutions for the system do not exist as the system runs into convergence issue for parameterization with ς_Ξ < 0.43.

Source: Authors' calculations.

Table 5

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 probability of not having drug confiscated by the government 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

Table 6

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 probability of successfully producing drug 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**

Figure 1

Permanent increase in probability of not having drugs confiscated in Country A

A one percent increase in π from initial value

(Absolute deviations from baseline)

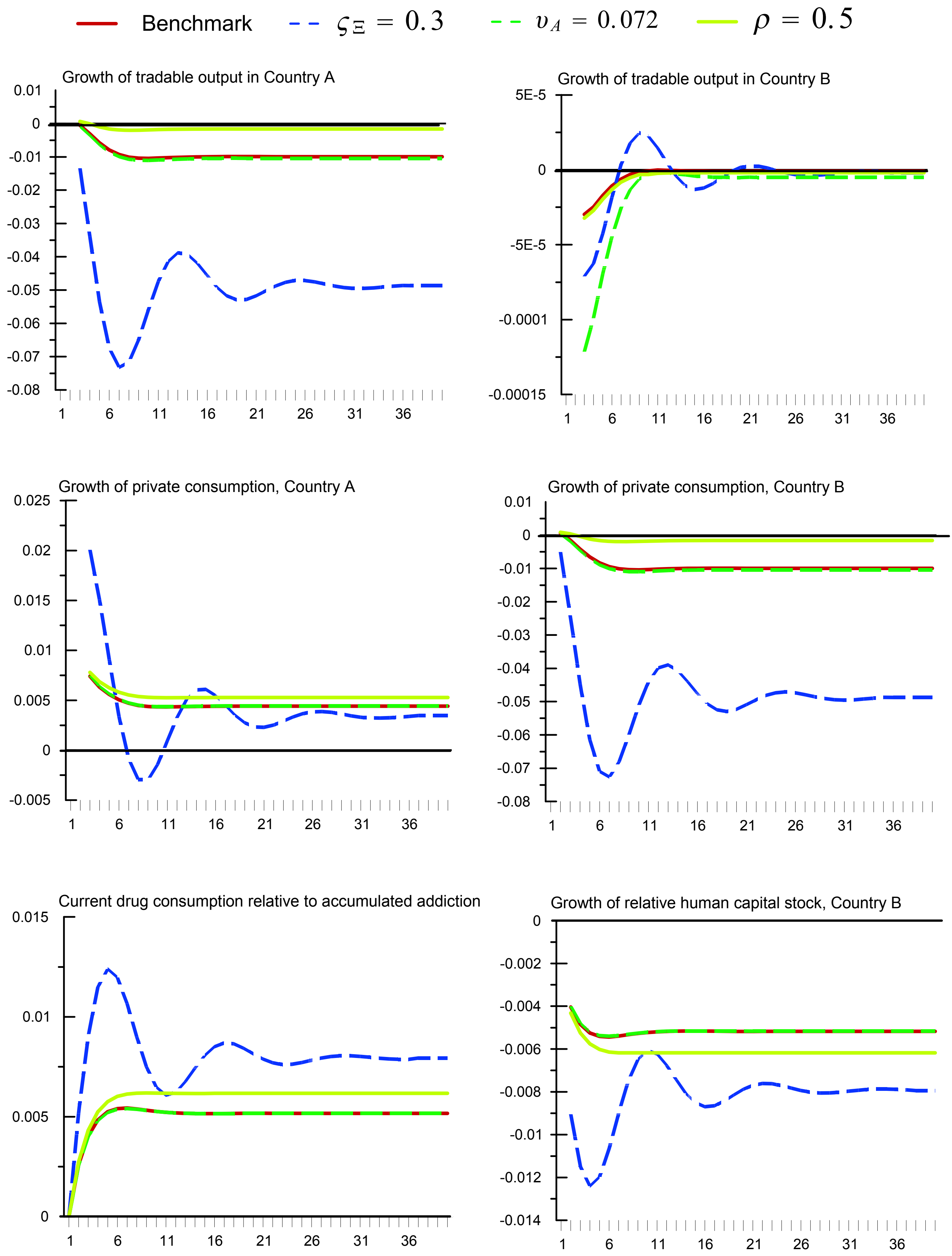


Figure 2

Permanent decrease in the probability of successfully producing drug in Country B

A one percent decrease in ***q*** from initial value

(Absolute deviations from baseline)

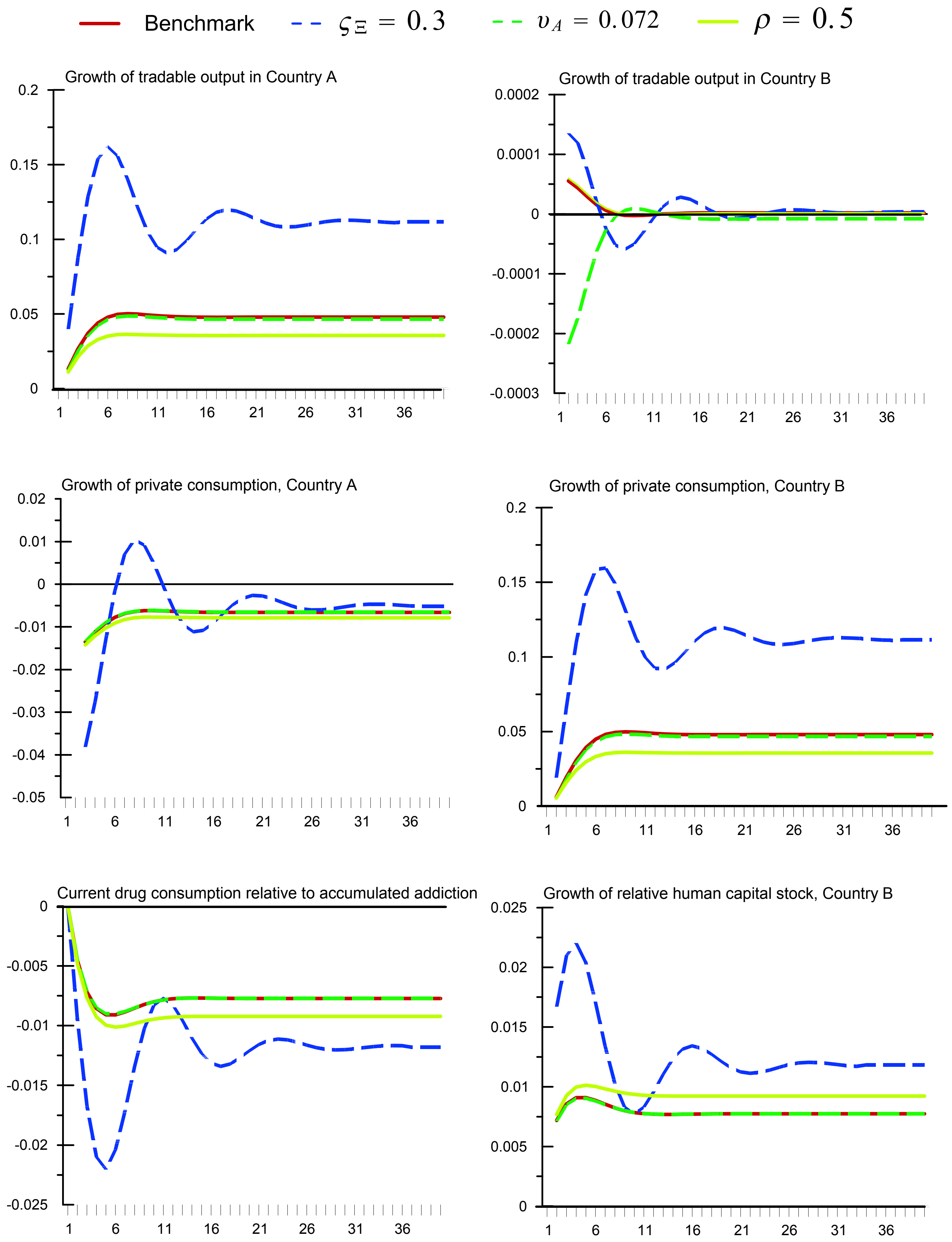


Figure 3

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)

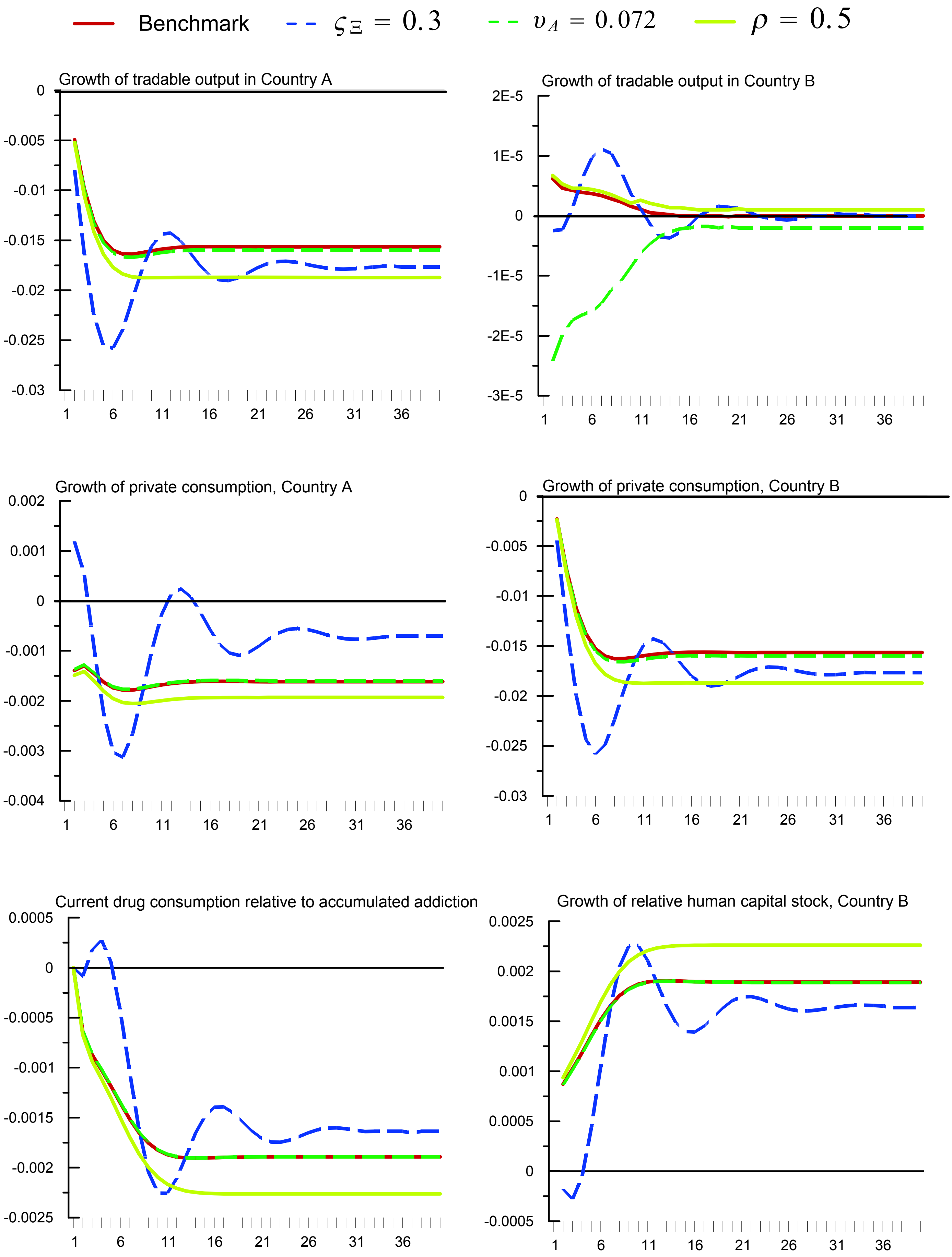
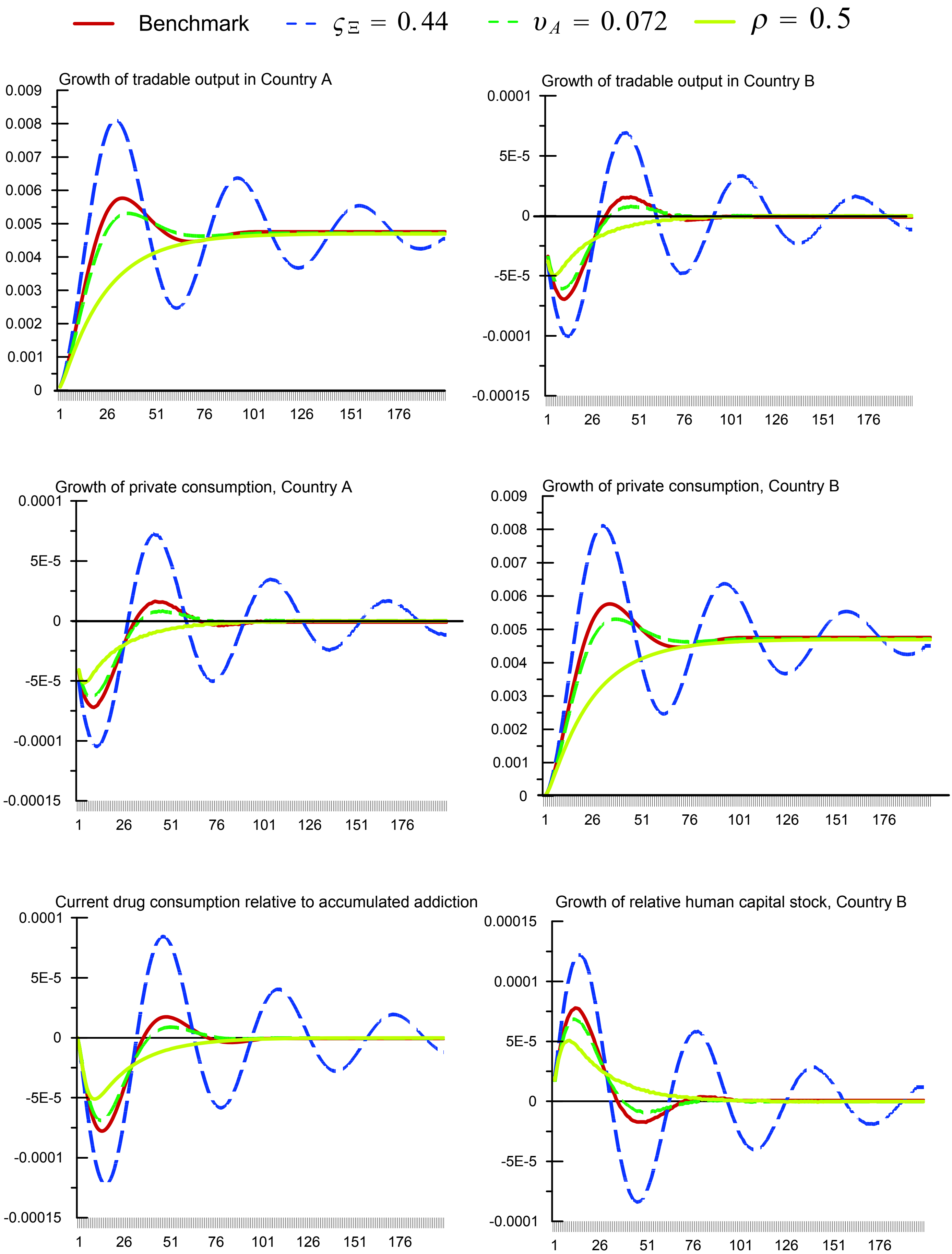


Figure 4

Permanent increase in the tax rate on guns sales

A one percent in τ_G from initial value

(Absolute deviations from baseline)



DISCUSSION PAPERS IN ECONOMICS

2019/2 Pengfei Jia and King Yoong Lim, Police Spending and Economic Stabilization in a Monetary Economy with Crime and Differential Human Capital.

2019/1 King Yoong Lim and Diego Morris, Modeling the Drugs and Guns Trade in a Two-Country Model with Endogenous Growth.

2018/3 Pengfei Jia and King Yoong Lim, Tax Policy and Toxic Housing Bubbles in China.

2018/2 Yousef Makhlouf, Trends in Income Inequality.

2018/1 Dimitrios Bakas and Athanasios Triantafyllou, The Impact of Uncertainty Shocks on the Volatility of Commodity Prices.

2017/9 Eghosa Igudia, Rob Ackrill and Simeon Coleman, *Entrepreneurial Responses to Austerity: The Role of the Informal Sector*.

2017/8 Rahmi Cetin and Robert Ackrill, *Openness and Growth in Challenging Times: Analysing the Trade-Growth Nexus in Slovakia*.

2017/7 Dimitrios Bakas and Yousef Makhlouf, *Can the Insider-Outsider Theory explain Unemployment Hysteresis in the OECD Countries?*

2017/6 Dimitrios Bakas, Georgios Chortareas and Georgios Magkonis, *Volatility and Growth: A not so Straightforward Relationship.*

2017/5 Will Rossiter, *Prospects and Challenges for City Region Devolution in Nottingham and the East Midlands.*

2017/4 Chunping Liu and Zhirong Ou, *What determines China's housing price dynamics? New evidence from a DSGE-VAR.*

2017/3 Morakinyo O. Adetutu and Thomas G. Weyman-Jones, *Fuel subsidies versus market power: is there a countervailing second best welfare optimum?*

2017/2 Robert Mullings, *Do Institutions moderate Globalization's effect on Growth?*

2017/1 Anthony J Glass, Karligash Kenjegalieva, Victor Ajayi, Morakinyou Adetutu, Robin C. Sickles, *Relative Winners and Losers from Efficiency Spillovers in Africa with Policy Implications for Regional Integration*.

2016/4 Sara Ornati, *International Environmental Agreements and Domestic Politics*.

2016/3 Yanhui Zhu, Jingwen Fan and Jon Tucker, *The impact of UK monetary policy on gold price dynamics*.

2016/2 John Ebireri and Alberto Paloni, *Bank Development and a Lower Degree of Sophistication and Diversification of Developing Countries' Exports*.

2016/1 Robert Mullings and Aruneema Mahabir, *Growth by Destination: The Role of*

Trade in Africa's Recent Growth Episode.

2015/1 Andrew Atherton, João R. Faria, Dongxu Wu and Zhongmin Wu, *Human Capital, Entrepreneurial Entry and Survival*.

2014/5 Leighton Vaughan Williams, *The US Supreme Court and the 'Affordable Care Act': An Exercise in Closed-Door Forecasting*.

2014/4 Juan Carlos Cuestas and Barry Harrison, *Unemployment Persistence in the EU15*.

2014/3 Francesco Marchionne and Sunny Parekh, *Growth, Debt, and Inequality*.

2014/2 Bo Jiang, Zhongmin Wu, Bruce Philp and Simeon Coleman, *Macro Stress Testing in the Banking System of China*.

2014/1 Eghosa Igudia, Rob Ackrill, Simeon Coleman and Carlyn Dobson, *Austerity Measures or Entrepreneurial Development? The case of the Nigerian Informal Economy*.

2013/5 Barry Harrison and Theodorus Wisnu Widjaja, *Did the Financial Crisis impact on the Capital Structure of Firms?*

2013/4 Geetha Ravishankar and Marie Stack, *The Gravity Model and Trade Efficiency: A Stochastic Frontier Analysis of Potential Trade*.

2013/3 Chunping Liu and Patrick Minford, *How Important is the Credit Channel? An Empirical Study of the US Banking Crisis.*

2013/2 Chunping Liu and Patrick Minford, *Comparing Behavioural and Rational Expectations for the US Post-War Economy.*

2013/1 Dan Wheatley, *Is it good to share? Debating patterns in availability and use of job share*.

2012/3 Simeon Coleman and Vitor Leone, *Time-Series Characteristics Of UK Commercial Property Returns: Testing For Multiple Changes In Persistence*.

2012/2 Otavio Ribeiro de Medeiros and Vitor Leone, *Multiple Changes in Persistence vs. Explosive Behaviour: The Dotcom Bubble*.

2012/1 Rob Ackrill and Simeon Coleman, *Inflation Dynamics In Central And Eastern European Countries*.

2011/4 Simeon Coleman, *Inflation Dynamics and Poverty Rates: Regional and Sectoral Evidence for Ghana.*

2011/3 Dan Wheatley and Zhongmin Wu, *Work, Inequality, And The Dual Career Household*.

2011/2 Simeon Coleman and Kavita Sirichand, *Fractional Integration and the Volatility Of UK Interest Rates*.

2011/1 Simeon Coleman, *Investigating Business Cycle Synchronization In West Africa*.

2010/11 Marie Stack and Eric Pentecost, *A Gravity Model Approach To Estimating Prospective Trade Gains in The EU Accession And Associated Countries*.

2010/10 Vitor Leone And Bruce Philp, *Surplus-Value And Aggregate Concentration In The UK Economy, 1987-2009*.

2010/9 Robert Ackrill and Adrian Kay, *WTO Regulations and Bioenergy Sustainability Certification – Synergies and Possible Conflicts.*

2010/8 Paul Alagidede, Simeon Coleman and Juan Carlos Cuestas, *Persistence Of Inflationary Shocks: Implications For West African Monetary Union Membership.*

2010/6 Bruce Philp and Dan Wheatley, *The time scarcity and the dual career household: competing perspectives*

2010/5 Juan Carlos Cuestas, Sebastián Freille and Patricio O'Gorman, *The media and public agendas: testing for media effects in Argentina Turing the Kirchner administration*

2010/4 Vitor Leone, *From property companies to real estate investment trusts: the impact of economic and property factors in the UK commercial property returns*

2010/3 Juan Carlos Cuestas and Paulo José Regis, *Purchasing power parity in OECD countries: nonlinear unit root tests revisited*

2010/2 Juan Carlos Cuestas and Bruce Philp, *Exploitation and the class struggle*

2010/1 Barry Harrison and Winston Moore, *Nonlinearities in Stock Returns for Some Recent Entrants to the EU*

2009/7 Joao R. Faria, Le Wang and Zhongmin Wu, *Debts on debts*

2009/6 Juan Carlos Cuestas and Luis A. Gil-Alana, *Unemployment hysteresis, structural changes,non-linearities and fractional integration in Central and Eastern Europe*

2009/5 Juan Carlos Cuestas and Javier Ordóñez, *Unemployment and common smooth transition trends in Central and Eastern European Countries*

2009/4 Stephen Dobson and Carlyn Ramlogan, *Is there a trade-off between income inequality and corruption? Evidence from Latin America*

2009/3 Juan Carlos Cuestas and Luís Alberiko Gil-Alana, *Further evidence on the PPP analysis of the Australian dollar: non-linearities, structural changes and fractional integration*

2009/2 Estefanía Mourelle and Juan Carlos Cuestas, *Inflation persistence and asymmetries: Evidence for African countries*

2009/1 Juan Carlos Cuestas and Barry Harrison, *Further evidence on the real interest rate parity hypothesis in Central and Eastern European Countries: unit roots and nonlinearities*

2008/16 Simeon Coleman, *Inflation persistence in the Franc Zone: evidence from disaggregated prices*

2008/15 Juan Carlos Cuestas and Paulo Regis, *Nonlinearities and the order of integration of order prices*

2008/14 Peter Dawson and Stephen Dobson, *The influence of social pressure and nationality on individual decisions: evidence from the behaviour of referees*

2008/13 Juan Carlos Cuestas and Barry Harrison, *Testing for stationarity of inflation in Central and Eastern European Countries*

2008/12 Juan Carlos Cuestas and Dean Garratt, *Is real GDP per capita a stationary process? Smooth transitions, nonlinear trends and unit root testing*

2008/11 Antonio Rodriguez Andres and Carlyn Ramlogan-Dobson, *Corruption, privatisation and the distribution of income in Latin America*

2008/10 Stephen Dobson and Carlyn Ramlogan, *Is there an openness Kuznets curve? Evidence from Latin America*

2008/9 Stephen Dobson, John Goddard and Frank Stähler, *Effort levels in contests: an empirical application of the Tullock model*

2008/8 Juan Carlos Cuestas and Estefania Mourelle, *Nonlinearities in real exchange rate determination: Do African exchange rates follow a random walk?*

2008/7 Stephen Dobson and John Goddard, *Strategic behaviour and risk taking in football*

2008/6 Joao Ricardo Faria, Juan Carlos Cuestas and Estefania Mourelle, *Entrepreneurship and unemployment: A nonlinear bidirectional causality?*

2008/5 Dan Wheatley, Irene Hardill and Bruce Philp, *"Managing" reductions in working hours: A study of work-time and leisure preferences in the UK industry*

2008/4 Adrian Kay and Robert Ackrill, *Institutional change in the international governance of agriculture: a revised account*

2008/3 Juan Carlos Cuestas and Paulo José Regis, *Testing for PPP in Australia: Evidence from unit root test against nonlinear trend stationarity alternatives*

2008/2 João Ricardo Faria, Juan Carlos Cuestas and Luis Gil-Alana, *Unemployment and entrepreneurship: A Cyclical Relation*

2008/1 Zhongmin Wu, Mark Baimbridge and Yu Zhu, *Multiple Job Holding in the United Kingdom: Evidence from the British Household Panel Survey*

DISCUSSION PAPERS IN POLITICAL ECONOMY

2006/3 Ioana Negru, *On Homogeneity and Pluralism within Economics Schools of Thought*

2006/2 David Harvie and Bruce Philp, *Learning and Assessment in a Reading Group Format or Reading Capital… For Marks*

2006/1 David Harvie, Bruce Philp and Gary Slater, *Regional Well-Being and 'Social Productivity' in Great Britain'*

2004/2 Massimo De Angelis and David Harvie, *Globalisation? No Question: Foreign Direct Investment and Labour Commanded*

2004/1 David Harvie, *Value-Production and Struggle in the Classroom, or, Educators Within, Against and Beyond Capital*

DISCUSSION PAPERS IN APPLIED ECONOMICS AND POLICY

2007/2 Juan Carlos Cuestas, *Purchasing Power Parity in Central and Eastern European Countries: An Analysis of Unit Roots and Non-linearities*

2007/1 Juan Carlos Cuestas and Javier Ordóñez, *Testing for Price Convergence among Mercosur Countries*

2006/2 Rahmi Cetin and Robert Ackrill, *Foreign Investment and the Export of Foreign and Local Firms: An Analysis of Turkish Manufacturing*

2006/1 Robert Ackrill and Adrian Kay, *The EU Financial Perspective 2007-2013 and the Forces that Shaped the Final Agreement*

2004/5 Michael A. Smith, David Paton and Leighton Vaughan-Williams, *Costs, Biases and Betting markets: New evidence*

2004/4 Chris Forde and Gary Slater, *Agency Working in Britain: Character, Consequences and Regulation*

2004/3 Barry Harrison and David Paton, *Do 'Fat Tails' Matter in GARCH Estimation? Stock market efficiency in Romania and the Czech Republic*

2004/2 Dean Garratt and Rebecca Taylor, *Issue-based Teaching in Economics*

2004/1 Michael McCann, *Motives for Acquisitions in the UK*

2003/6 Chris Forde and Gary Slater, *The Nature and Experience of Agency Working in Britain*

2003/5 Eugen Mihaita, *Generating Hypothetical Rates of Return for the Romanian Fully Funded Pension Funds*

2003/4 Eugen Mihaita, *The Romanian Pension Reform*

2003/3 Joshy Easaw and Dean Garratt, *Impact of the UK General Election on Total Government Expenditure Cycles: Theory and Evidence*

2003/2 Dean Garratt, *Rates of Return to Owner-Occupation in the UK Housing Market*

2003/1 Barry Harrison and David Paton, *The Evolution of Stock Market Efficiency in a Transition Economy: Evidence from Romania.*