Modelling the Cocaine and Heroin Markets in the Era of Globalization and Drug Reduction Policies

Cláudia Costa Storti
and
Paul De Grauwe

1. Introduction

Over the last twenty years, the use of cocaine and heroin in the world has continued to increase. According to UNODC (2007), between 1992 and 2005, world consumption of these drugs rose by about 3.2%. These growth rates were 7.3% and 3.4% in Europe and 1.8% and 1.1% in the US during the same period. Public policies to combat the drug phenomenon, i.e. those geared towards reducing drug supply have been extensive. In Europe, according to the existing information about six countries published by the EMCDDA (2007) the share of the overall public drug-related expenditure devoted to supply reduction policies, i.e. law enforcement, varied from 40% to 77% in 2005 (excluding Hungary where they only represented 24%). In the US, according to the White House national drug control strategy (2007), the percentage of drug control funding allocated to supply reduction activities has increased from 53% in 2001 to 63% in 2007.

A further understanding of the drug supply phenomena seems urgent. Despite the public expenditure devoted to restrain drug supply, illicit production of drugs such as cocaine and heroin has continued to increase and retail prices in Europe and the US have fallen significantly in the last twenty years. The latest available data for 2005 and 2006 show that retail prices of cocaine and heroin fell to less than half of their levels of 1990. Empirical research has showed that drug use is responsive to drug prices[1]. Thus, the observed price decline may be responsible for the increased use of cocaine and heroin.

In this paper we develop an economic model of demand and supply and of the price formation process of illicit drugs (cocaine and heroin). We model the cocaine and heroin markets in three steps. First we concentrate on the retail markets of these drugs. This will lead to the demand side of the model. Second, we model the production of cocaine and heroin in the producing countries. This will lead to the supply side of the model. Third, we link the demand and supply sides by modelling the export-import business of cocaine and heroin.

We will then use this model to analyze how globalization has influenced the business of producing, trafficking and consuming drugs. Our main argument will be that the

[1] Different studies point to a price elasticity faced by aggregate demand for cocaine relatively small but different from zero. See Caulkins et al. (1995), Caulkins (2001), Bretteville-Jensen and Biorn (2004), Abt Associates (2000), Dave (2004), Grossman (2004).

different ways globalization affects the phenomena contribute to explaining these empirical puzzles. Furthermore, we will analyze the effects of law enforcement policies at different levels of the production and trafficking of drugs. We will suggest that these law enforcement policies risk loosing the battle against the forces of globalization.

The paper is organized as follows. Section 2 presents the different empirical puzzles in the cocaine and heroin markets. Section 3 develops the retail side of the model, section 4 the supply side and section 5 links the two by modelling the export-import of the drugs. In section 6 we bring together the different effects of globalization on the markets for cocaine and heroin.

2. Recent developments in the cocaine and heroin markets

During the last twenty five years important empirical phenomena have occurred in the cocaine and heroin markets. First, retail prices of these drugs have declined significantly. We show the evolution of these prices in the US and European retail markets since 1990 in figure 1. (Note that since the early 2000s a stabilization of these prices seems to have occurred and even a surge of heroin prices in the US retail market).

Second, the producer prices of cocaine and heroin have increased or remained stable over the same period. These are the prices paid out at the farms gate in the producing countries. We show the evidence for cocaine in figure 2. We observe that the farm-gate prices of coca leafs have more than doubled since 1990. The price data for heroin are less comprehensive but the evidence suggests that these trends have been similar for heroin, see United Nations, World Drug Report 2007.

Third, and related to the previous observations, the intermediation margins in the cocaine and heroin business have declined dramatically over the same period. We show the evidence in figures 3 and 4. Figure 3 shows the international intermediation margin, i.e. the margin between the wholesale price in the drug importing country and the price paid to the producers in the exporting countries. This can also be called the export-import margin. Figure 4 shows the intermediation margin between the retail price and the wholesale price in the drug consuming countries. We see that both these margins have collapsed since 1990 for both cocaine and heroin.

Fourth, the world production of cocaine and heroin has continued to increase. We show the evidence in figure 5.

Fifth, the evidence suggests that the worldwide consumption of cocaine and heroin has tended to increase. According to the Office on Drugs and Crime of the UN, consumption of both cocaine and heroin was 3% higher in 2005 as compared to 1992. These growth rates were 7.3% and 3.4% in Europe and 1.8% and 1.1% in the US during the same period

Figure 1

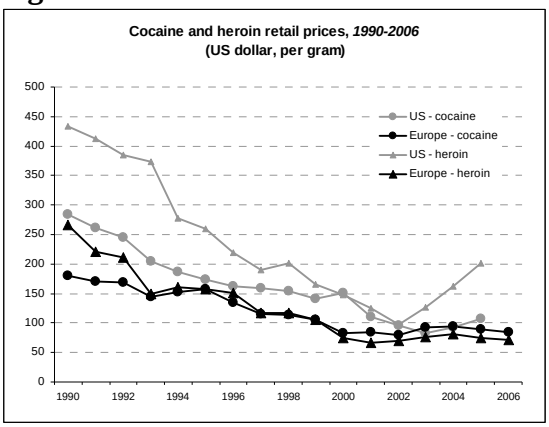
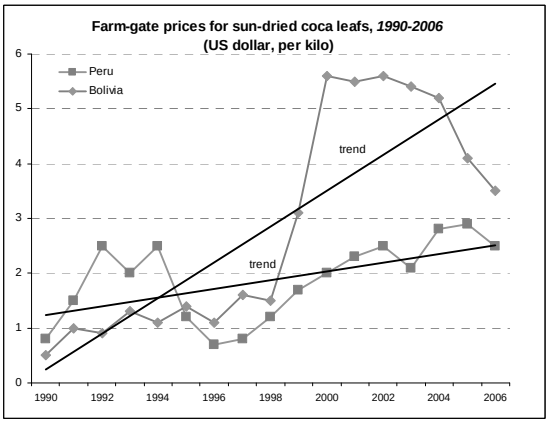


Figure 2



Source: United Nations, World Drug Report 2007
Office on Drugs and Crime, New York (pp 223, 228)
Note: Prices are adjusted for inflation

Figure 3

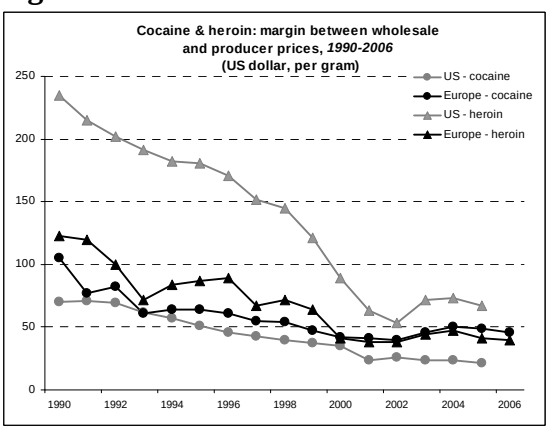
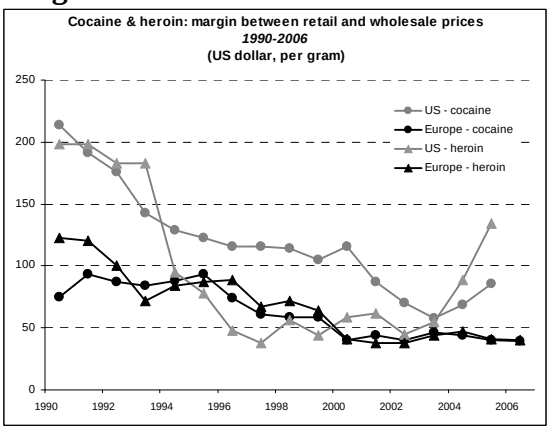
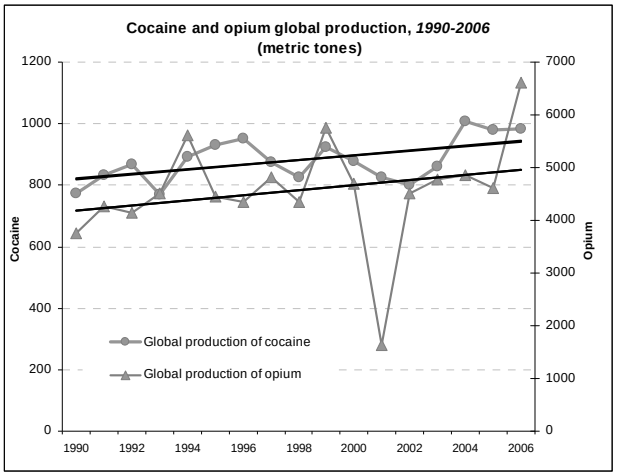


Figure 4



Source: Costa Storti and De Grauwe(2008)

Figure 5



Source: United Nations, World Drug Report 2007, Office on Drugs and Crime, New York, (p.64).
Notes:
(1) Straight lines are trend lines estimated by OLS. The estimated equations are:
Cocaine Y = 815 + 7.47X , where Y is the production and X is time
Heroin Y = 4200 + 43.0X , where Y is the production and X is time.
(2) US Department of State(2008) finds similar trends during 2002-06

Finally, during the same period supply containment policies have been intense, and in some countries like the US, these policies have been stepped up dramatically. According to Basov, et al. (2001), from 1980 to 2000, the DEA budget increased by a factor of three in real terms. Drug arrests in the US more than doubled during the same period. One could have expected that such an intensification of supply containment policies would have shown up in higher retail prices and declining consumption and production. Exactly the opposite occurred in the US. These are puzzling phenomena. Our theoretical model will attempt to makes sense of it.

3. The model for the retail drug market

We assume that the retail market is characterized by monopolistic competition, i.e. there are many suppliers of drugs, each of which has some limited local market power[2]. This local market power is the result of the importance that network externalities assume in this business. These have been described by many researchers.

[2] The model that will be presented in this section is an extension of the Krugman(1979) model. See also Feenstra(2006). It has its origin in the work of Chamberlin(1936) and Robinson(1933) on monopolistic competition.

The Matrix Knowledge Group (2007) concluded that in the UK the level of market entry is largely determined by the level of the personal contact a dealer entered through. *"Most successful dealers were able to adapt to new circumstances and exploit new opportunities. These often came about through chance meetings, although ethnic ties, selling to friends who were users",* i.e., successful dealers are those who are better in establishing personal networks. So their success depends on the contacts they are able to establish, the trust they are able to build either from their suppliers or from their clients. A drug user will prefer to buy from his regular supplier, accepting a higher price in order to guarantee that the drug is safe and the supplier is trustworthy.

In a broader international literature review Desroches F. (2007) assesses the nature and structure of drug markets, focusing on "upper level drug trafficking". He concludes that upper level dealers (i.e., the local monopolists) typically operate in crews or cells made up of core and fringe members, with a dealer who oversees all the important work (where sometimes there are some partnerships with one or two upper level traffickers) with employees for non-managerial tasks. The secrecy of their activities and their structures which are based on personal networks, prevents these drug syndicates from growing. Furthermore, kinship, friendship and ethnic bonds function as a basis for the establishment of new clients, where the capacity of each of these drug trafficking syndicates to enlarge their market share is also limited.

All this tends to create a market structure akin to monopolistic competition, in which drug dealers have a certain market power and apply a high markup initially. This markup tends to diminishes over time because new dealers are tempted to join the market. Thus a characteristic of this market structure is that there are no strong barriers deterring newcomers (see also Reuter and Haaga(1989)). Consequently, these markets benefit from a certain degree of competition leading to price declines.

3.1 The model

This local market power of the supplier is represented in our model by the assumption that each "upper level trafficker" or supplier faces a downward sloping demand curve for the drugs he sells. We assume there are *n* suppliers of drugs in the retail market.

The number of suppliers is endogenously determined in the long run by imposing a long term no profit condition.

The profit of supplier i (π_i) is defined as follows

$$\pi_i = p_i x_i - w l_i - p_m x_i \qquad (3.1)$$

where x_i is the quantity of the cocaine sold by i; p_i is the price charged; l_i is the number of "lower level dealers" employed by supplier i; we assume that the same wage, w, is paid to all "lower level dealers". Furthermore, p_m is the cost of one unit of the drug at the moment of import, so that the term $p_m x_i$ is the total cost of the imported drugs for firm i (for the upper level trafficker).

We assume a very simple linear technology guiding the demand of "lower level drug dealers" or employees by firm i,(the "upper level drug dealer i"):

$$l_i = \alpha + \beta x_i \qquad (3.2)$$

where β_i is the number of dealers needed to sell one unit of drugs (the marginal labour input coefficient). Put differently, $\frac{1}{\beta}$ is the marginal productivity of a lower level dealer in selling drugs.

Efficiency improvements can lead to an increase in the marginal productivity of dealing. Conversely, stricter law enforcement can have the effect of lowering the marginal productivity of dealing in drugs. The assumption is that when the number of arrests increases, more dealers will have to be used to traffic the same amount of drugs. We assume that law enforcement has a positive marginal productivity (more law enforcement leads to the imprisoning of more drug dealers), though at a declining rate, i.e. the efficacy of further law enforcement activity has diminishing returns.

Substituting (3.2) into (3.1) yields

$$\pi_i = p_i x_i - w(\alpha + \beta x_i) - p_m x_i \qquad (3.3)$$

The upper level drug dealer or firm i maximizes his profits. The first order condition for a maximum is given by the following expression

$$p_i = \frac{\eta}{\eta - 1}(\beta w + p_m) \qquad (3.4)$$

where η is the price elasticity of the demand for drugs of supplier *i* (expressed in absolute value).

It is important to stress here that the price elasticity, η, measures the reaction of drug users to a change in price asked by supplier *i*, assuming that other suppliers do not change their price. In our model of monopolistic competition, $\eta > 1$. This price elasticity is different from the price elasticity of the total demand for cocaine. Let us call the latter the market elasticity and represent it by ε. The market elasticity, ε, measures the extent to which drug users change their demand for drugs when the price of this drug (as applied by <u>all</u> drug suppliers) changes. The market elasticity, ε, is then lower than the elasticity, η, used here[3]. It can been shown that in order for the model of monopolistic competition to have an equilibrium $\varepsilon < \eta$ (Dixit and Stiglitz(1977)).

We recognize in equation (3.4) the typical markup condition of price over marginal cost. The marginal cost is $\beta w + p_m$ and consists of two components, the marginal cost of dealing drugs by the lower level trafficker (βw) and the marginal importing cost of the drug (p_m). $\frac{\eta}{\eta - 1} > 1$ is the markup.

It can be useful to express equation (3.4) in a different form, i.e.

$$m_i = \frac{\eta}{\eta - 1}(\frac{\beta w}{p_m} + 1) \qquad (3.5)$$

where $m_i = \frac{p_i}{p_m}$ is the intermediation margin in the retail market. Note that this margin includes both the wages paid to the lower level traffickers and the profits of the upper level dealer.

[3] Caulkins and Hao(2008), have an interesting discussion about the European and the US demand elasticities for cocaine and heroin. They put the market elasticity for the US within a range of 0.5 to 1 (absolute values). See Abt Associates (2000), Bretteville-Jensen and Biorn (2004), Caulkins et al. (1998), Caulkins (2001), , Dave (2004), Grossman (2004). The estimates of the price elasticity ε obtained in these studies typically are below 1 (but larger than 0).

Equation (3.4) allows us to gauge the impact of exogenous changes on the retail price of the drug. For example, an increase in the cost of imported drugs leads to a more than proportional increase in the price of the drug, i.e.

$$\frac{\partial p_i}{\partial p_m} = \frac{\eta}{\eta - 1} \tag{3.6}$$

It should be stressed that these effects apply to the short-run. In the long run, the profits of the drug suppliers are competed away by the entry of new drug suppliers. Long run equilibrium is obtained by imposing a zero profit condition $\pi_i = 0$. We will also impose the condition that the equilibrium is symmetric, i.e. that prices and quantities are identical across drug suppliers. This allows us to concentrate on the representative drug supplier without subscript, i.e. to focus on a representative upper level drug dealer.

Thus, from (3.3) and dropping the subscript *i*, we obtain the long run equilibrium condition

$$px - w(\alpha + \beta x) - p_m x = 0 \tag{3.7}$$

Rearranging leads to

$$p = w(\frac{\alpha}{x} + \beta) + p_m \tag{3.8}$$

It can be seen that this amounts to setting price equal to average cost. We rewrite this equation to obtain the long term equilibrium value of the intermediation margin

$$m = \frac{w}{p_m}(\frac{\alpha}{x} + \beta) + 1 \tag{3.9}$$

We can derive the long run effect of a change in p_m. For example, the long term impact of a increase in the import price of drugs, p_m, on the retail price of cocaine, p, results of the derivative of p with respect to p_m in equation (3.8). This yields:

$$\frac{\partial p}{\partial p_m} = 1 \tag{3.10}$$

Comparing (3.10) with (3.6) we see that the long term effect of a higher import price of drugs is smaller than the short-term effect. In the short-run, the higher import price leads to an "overshooting" of the price, i.e., short run retail price increases more than proportionally to the increase in the imported drug price, reflecting the fact that the upper level dealers maintain a markup in the short run. This result is confirmed by the Matrix Knowledge Group (2007). In this large scale project, where interviews were made to individuals in prison convicted of serious drug-related offences, it is concluded that *"where market fluctuations did lead to increased purchase prices, dealers maintained margins by passing these increases on to customers."*

Finally, and in order to close the model we introduce the condition that the demand for drugs is equal to the supply. Total demand is equal to the consumption[4] (c) of the representative consumer times the size of the population N (the prevalence), i.e. cN. In equilibrium $cN = x$. We substitute this expression in (3.8)

$$p = w(\frac{\alpha}{cN} + \beta) + p_m \qquad (3.11)$$

The equilibrium of the model is fully described by equations (3.4) and (3.11). These two equations determine the equilibrium value of the retail price (p) and the consumption of drugs (c), in the short and long term, respectively. Note that we could also represent the equilibrium of the model in terms of the intermediation margin m, using equations (3.5) and (3.9).

We represent the short term and long term equilibrium expressed in equations (3.4) and (3.11) graphically in figure 3.1. The PP-line is the graphical expression of the short term showed in equation (3.4). We assume here that the retail demand curves are linear. As a result, the elasticity η is declining for increasing values of c, i.e., the higher the drug use the less sensitive drug demand is to price changes. This feature of the demand curve is consistent with the evidence suggesting that high drug users become addicted (dependent) so that their demand becomes less price sensitive (see Caulkins and Hao(2008)). This produces an upward sloping PP-line. The intuition behind the upward slope is that with a higher level of drug consumption the market

[4] Consumption of a representative drug user should be identical to the product of the amount of cocaine per dose, purity and the number of doses a day, taking into account that this pattern varies over the year (Singleton at al. 2006).

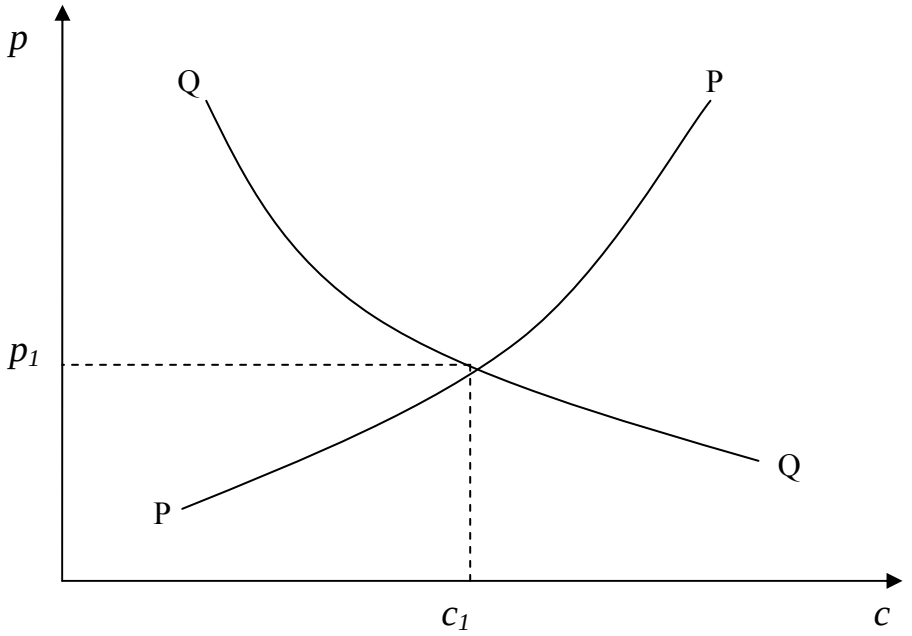
power of the drug supplier is increased, allowing him to apply a higher markup. This leads to a higher retail price.

The QQ-line is the graphical representation of the long-run equilibrium condition (3.11). The negative slope (which is readily seen from equation (3.11)) expresses the fact that QQ is derived from the average cost curve. Thus as consumption increases, firms' average costs decline. In the long run this leads to a declining retail price.

The equilibrium values of the price and the consumption of the representative drug user are given by the intersection point of the PP- and QQ-lines.

We can use this model to analyze important policy questions. The first question we analyze is how drug seizures affect the retail market. The second question is how globalization affects the market.

Figure 3.1: Equilibrium of the retail market



3.2 Impact of seizures

The way we model seizures is as follows. We introduce in equation (3.1) the probability that a certain percentage of drugs sold in the retail market is seized. This leads to a new definition of the profits of supplier i:

$$\pi_i = p_i x_i (1-s) - w l_i - p_m x_i \qquad (3.12)$$

where s is the probability that the drug supplied by i will be seized. Note that π_i now has to be interpreted as expected profits.

The supplier of drugs i maximizes his profits. The first order condition for a maximum is now given by

$$p_i = \frac{\eta}{\eta - 1}\left(\frac{1}{1-s}\right)(\beta w + p_m) \qquad (3.13)$$

This equation has the same interpretation as (3.4), i.e. it describes the short-term equilibrium. We observe from (3.13) that when the probability of seizures increases, the "upper level trafficker" will raise retail price. Because of the existence of a markup ($\frac{\eta}{\eta - 1}$) the price increase will be a multiple of the increase in the probability of seizures.

We can rewrite equation (3.13) so as to explain the retail margin m_i, as we did in equation (3.5).

$$m_i = \frac{\eta}{\eta - 1}\left(\frac{1}{1-s}\right)(\frac{\beta w}{p_m} + 1) \qquad (3.14)$$

As before, long run equilibrium is obtained by imposing a zero profit condition π_i = 0. This yields:

$$p = \left(\frac{1}{1-s}\right)\left[w(\frac{\alpha}{x} + \beta) + p_m \right] \qquad (3.15)$$

or in the form of margins

$$m = \left(\frac{1}{1-s}\right)\left[\frac{w}{p_m}(\frac{\alpha}{x} + \beta) + 1 \right] \qquad (3.16)$$

Since in equilibrium $x = cN$ (3.15) becomes

$$p = \left(\frac{1}{1-s}\right)\left[w(\frac{\alpha}{cN} + \beta) + p_m \right] \qquad (3.17)$$

We can now analyze the effect of changes in the probability of seizures brought about by tighter law enforcement. We do this in figure 3.2 using the same graphical procedure as in figure 3.1. An increase in *s* has the effect of shifting both the PP- and the QQ-curves upwards. However, it can be shown that the upward shift of the PP-curve is higher than that of the QQ-curve. This can be seen by taking the partial derivative of *p* with respect to *s* in equations (3.13) and (3.17). We obtain

From equation (3.13): $$\frac{\partial p}{\partial s} = \frac{\eta}{\eta - 1}\left(\frac{1}{(1-s)^2}\right)(w\beta + p_m) \qquad (3.18)$$

From equation (3.17): $$\frac{\partial p}{\partial s} = \left(\frac{1}{(1-s)^2}\right)(w\beta + p_m) \qquad (3.19)$$

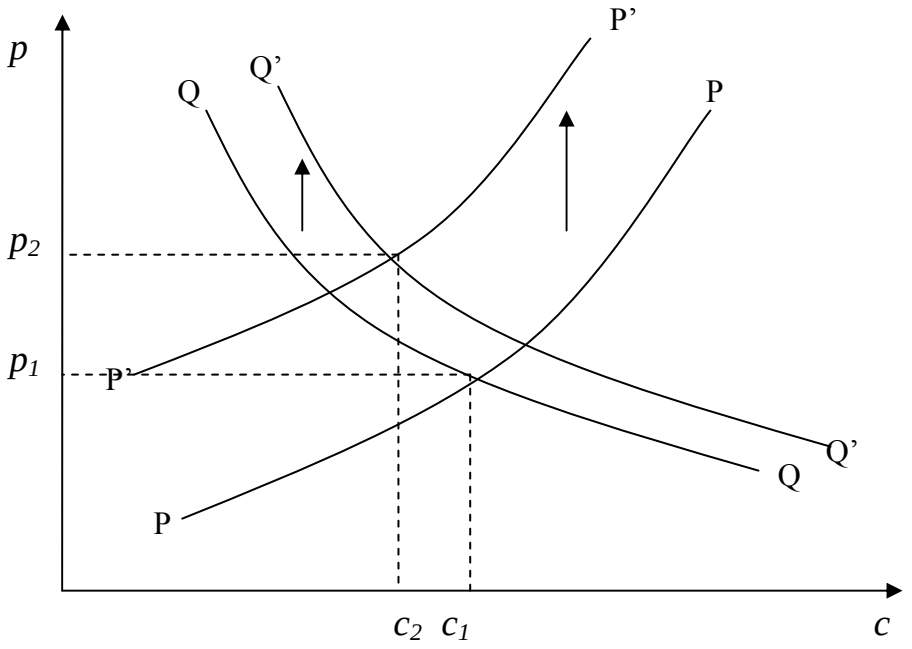
It can be seen that (3.18) > (3.19) showing that the upward shift of the PP-curve is higher than that of the QQ-curve.

We conclude that an increase in the probability of seizures raises the retail price of drugs and reduces the amount of drug use. The latter effect follows from the fact that drug users are sensitive to a price increase. Note also that as the price increases and the drug use declines, the price elasticity, η, increases.

Finally, it can also be shown that an increase in seizures increases the intermediation margin *m*. This increase in the margin can be interpreted as in increase in the risk premium associated to the business of drug dealing.

There are other risks that could be analyzed in our model. One is the risk of incarceration. This risk will tend to introduce a risk premium in the wage of the low level traffickers. In addition, it leads to an increase in the risk premium that upper level dealers have to receive in order to deal the drug. This has the same qualitative effect as the risk of seizures, i.e. it shifts both curves upwards leading to a higher retail price. Note that in this case the increase in the retail price reflects a higher profit margin which is necessary to induce agents to engage in dealing drugs. (See Caulkins and Reuter(1998) for an in-depth analysis). We will return to this risk in section 5.

Figure 3.2 : effect of increase in probability of seizures



3.3 The effects of globalization

The model also allows us to analyze the effects of globalization. There are several ways globalization enters the model. The first way is by reducing the import cost of drugs (p_m), which will be analyzed in greater detail in section 5. The second way is by increasing the supply of drug dealers. We focus on the latter here. The total demand for drug dealers is

$$L_D = \sum_{i=1}^{n} l_i$$

In equilibrium $L_D = L_S$. An increase in the supply of drug dealers leads to excess supply and thus to a decline in dealers' wage. We can now analyze the implications of this wage decline using equations (3.13) and (3.17) and their graphical representations. This is shown in figure 3.3. Both the PP- and the QQ-curves shift downwards producing a decline in the retail price (and in the intermediation margin). The effect on consumption however is ambiguous and depends on the parameters of the model.

The downward shift in the PP-curve is obtained by taking the partial derivative of *p* with respect to *w* in equation (3.13). This yields

$$\frac{\partial p}{\partial w} = \frac{\eta}{(\eta - 1)}\left(\frac{1}{1-s}\right)\beta \qquad (3.20)$$

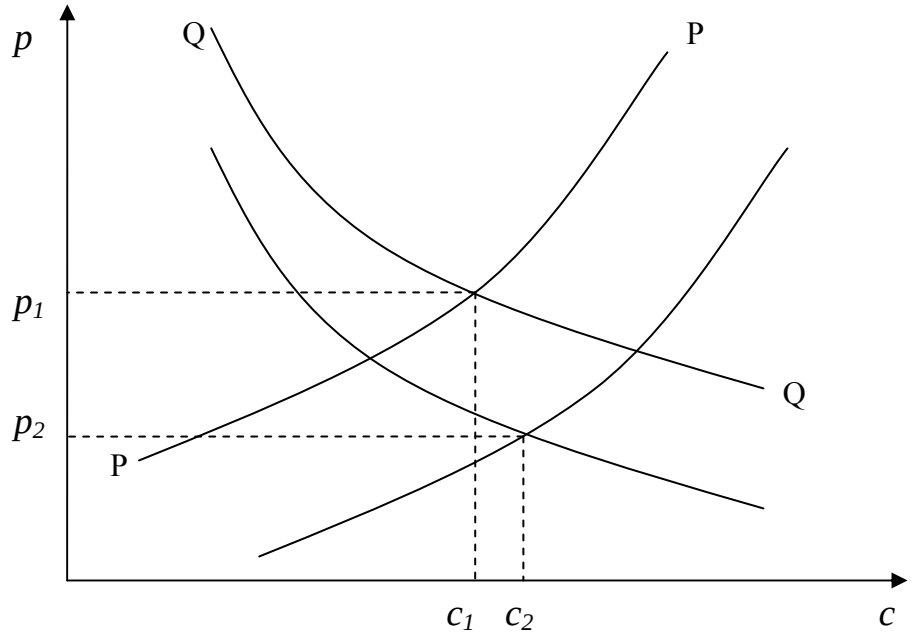
The downward shift of the QQ-curve is obtained by taking the partial derivative of p with respect to w in equation (11). This yields

$$\frac{\partial p}{\partial w} = \left(\frac{1}{1-s}\right)\left(\frac{\alpha}{cN} + \beta\right) \qquad (3.21)$$

It is not a-priori clear which expression is bigger. We know, however, that when c is high the elasticity η tends to diminish (producing a high markup). Thus for sufficiently high levels of c the downward shift in the PP-line will exceed the downward shift in the QQ-line, producing an increase in consumption. This is the case shown in figure 3.3.

From the previous analysis we note that globalization and supply containment policies have opposite effects on the retail price of drugs. This implies that, as globalization is an ongoing process, it forces the authorities to continuously increase the amount of resources used in supply containment policies in order to prevent the retail price from declining. Taking into account that law enforcement may be subject to diminishing returns, it is very likely that the effects of globalization may prevail.

Figure 3.3: Effect of globalization – increasing supply of low level drug dealers



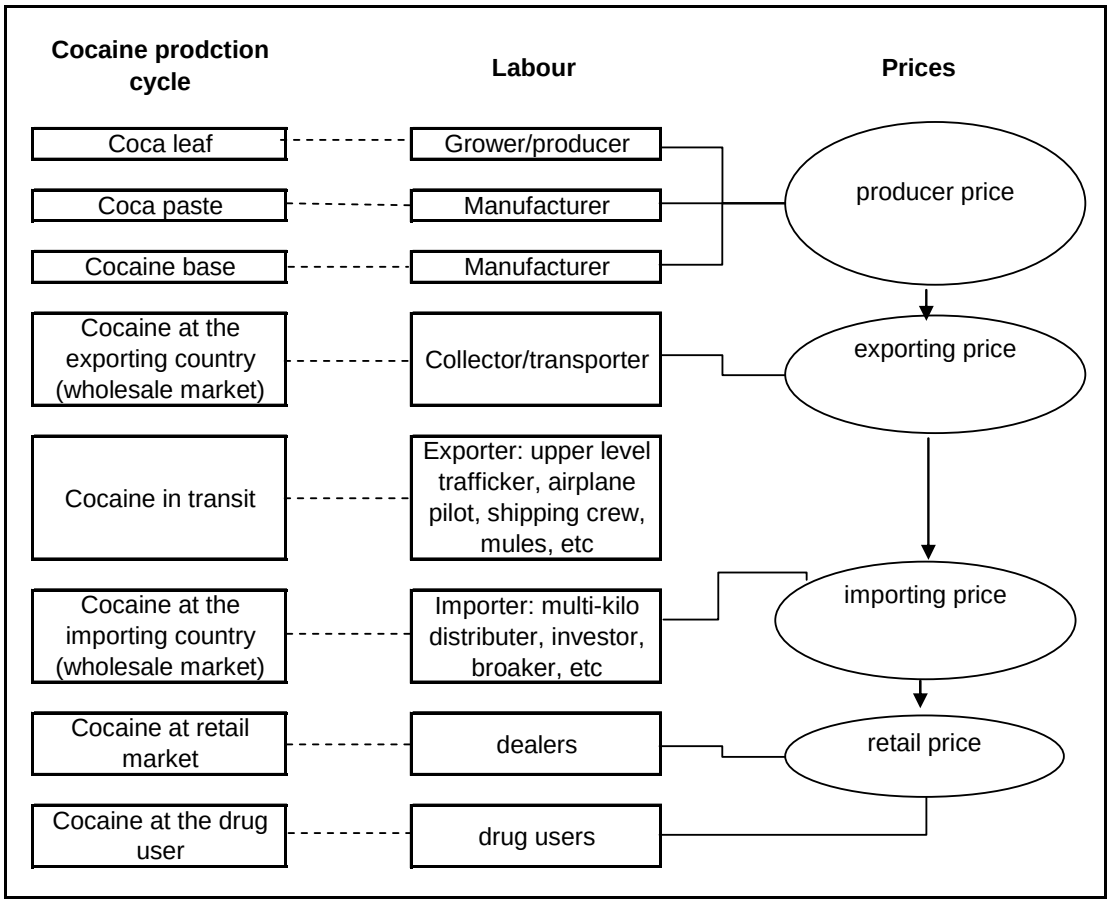
3.4 Demand and supply policies compared

The retail model derived in the previous sections allows us to shed some light on the relation between demand and supply policies. Demand policies (prevention, treatment and harm reduction), if successful, reduce drug consumption (c) of the representative user. As previously shown, a decline of c has the effect of increasing the price elasticity (η) of the demand for drugs. Put differently, the success of demand policies can be gauged by their capacity of increasing the price sensitivity of the demand for drugs (which also implies that the power of the traffickers is reduced). This feature of successful demand policies in turn affects the effectiveness of supply containment policies. The reason is the following. A reduction of the supply of drugs raises the retail price. With a higher price elasticity of the demand for drugs, this supply induced price increase has a stronger negative effect on consumption. As a result, supply policies become more effective in reducing drug use. Thus, our model of the retail market has as an implication that when supply policies are combined with demand policies, the former become more effective in reducing drug use.

4. Deriving the producers' supply curve

In this section we derive the producers' supply of drugs in the source countries. We will focus our analysis on the first step of the processing stages, shown in Table 1, when coca leaf is produced. For the sake of simplicity we will not take into consideration the trans-shipment of precursor chemicals and intermediate products such as paste and base presented in Figure 4.1.

Table 4.1



We assume that the supply of drugs in the producing country (e.g. Colombia) is organized in a perfectly competitive market[5].

We start from a Cobb-Douglas production function of an individual producer *i*:

$$Q_{i_C} = A_C L_C^{\alpha} G_C^{\beta} (1 - p_e) \qquad (4.1)$$

[5] See also Kennedy et al. (1993).

where Q_C is the output of cocaine, L_C is the use of labour in the cocaine production, G_C is the use of land in the cocaine production, p_e is the probability of eradication, i.e. the share that each producer expects to be subject to the eradication policies followed by the law enforcement authority. We assume decreasing returns so that $\alpha + \beta < 1$. Finally, A_C measures total factor productivity.

The budget constraint of the individual producer is

$$C = wL_C + rG_C \tag{4.2}$$

where C is the cost of producing cocaine given the wage rate, w, and the price of land, r.

The producer minimizes his cost, C, subject to the production function. This cost minimization allows the producer to determine the optimal use of labour and land in the production process, i.e.

$$\frac{G_C}{L_C} = \frac{\beta}{\alpha}\frac{w}{r} \tag{4.3}$$

Thus, when wage costs increase relative to land costs, less labour and more land will be used in the production of cocaine.

Equations (4.3) and (4.1) allow us to derive the optimal demand of labour and land in the cocaine sector:

$$L_C = Q^{\gamma} A_C^{-\gamma} \left(\frac{\alpha}{\beta}\frac{r}{w}\right)^{\beta\gamma} \left(\frac{1}{1-p_e}\right)^{\gamma} \tag{4.4}$$

$$G_C = Q^{\gamma} A_C^{-\gamma} \left(\frac{\beta}{\alpha}\frac{w}{r}\right)^{\alpha\gamma} \left(\frac{1}{1-p_e}\right)^{\gamma} \tag{4.5}$$

where $\gamma = \dfrac{1}{\alpha + \beta} > 1$

We note that an increase in the probability of eradication leads to a decline in the demand for labour and land in the same proportions.

The next step in the analysis is to derive the cost function. This is obtained by substituting the labour and land demand from (4.4) and (4.5) into the budget constraint (4.2). This yields

$$C = \Omega Q^{\gamma} A_C^{-\gamma} w^{\alpha\gamma} r^{\beta\gamma} \left(\frac{1}{1-p_e} \right)^{\gamma} \tag{4.6}$$

where $\Omega = \left(\frac{\alpha}{\beta}\right)^{\beta\gamma} + \left(\frac{\beta}{\alpha}\right)^{\alpha\gamma}$

Finally we derive the supply curve. This is obtained by setting marginal cost equal to the producer price and solving for Q_C. We then obtain

$$Q = \Omega P_C^{\frac{1}{\gamma-1}} A_C^{\frac{\gamma}{\gamma-1}} w^{\frac{-\alpha\gamma}{\gamma-1}} r^{\frac{-\beta\gamma}{\gamma-1}} \left(\frac{1}{1-p_e} \right)^{\frac{-\gamma}{\gamma-1}} \tag{4.7}$$

Thus producers react to a price increase by raising output. The price elasticity of the supply of output is given by $\frac{1}{\gamma-1}$ which is larger than 1. It means that when price increases, producers increase cocaine production more than proportionally. The size of the output increase depends on the volume of capital and labour used to produce one unit of cocaine, i.e. on γ.

For a given γ, the relation between price and quantities supplied is shown in figure 4.3. The relation is log-linear, i.e. if we transform price and quantities supplied in logs we obtain a linear relationship. Given that the price elasticity is higher than 1, the supply curve is relatively flat.

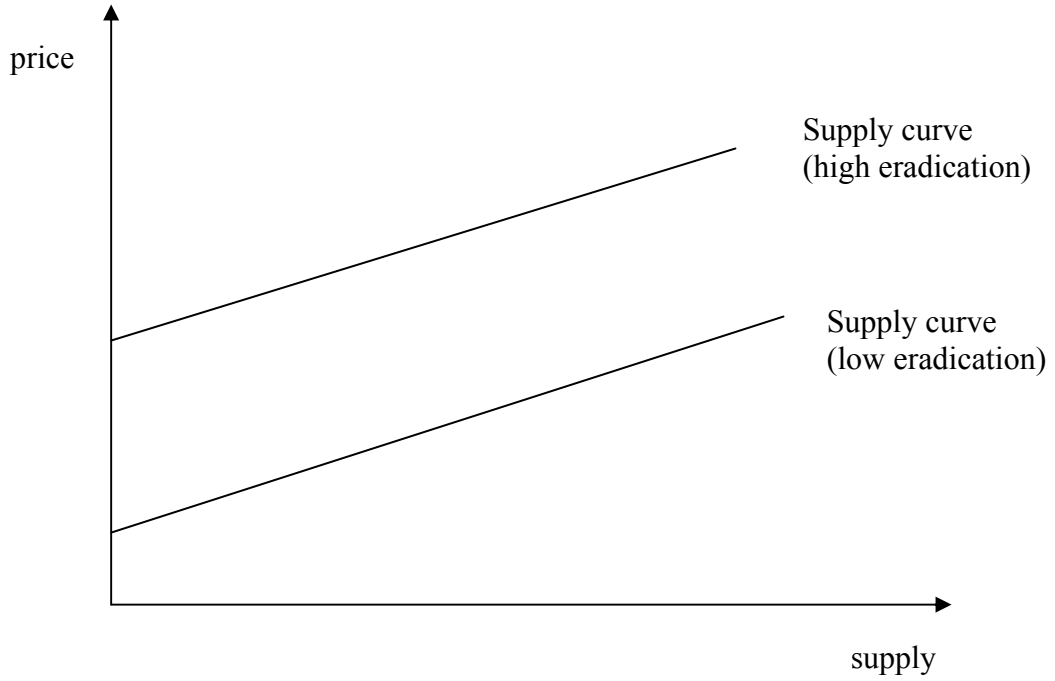
Eradication programs reduce the supply of output. Its impact is measured by the expression $\frac{-\gamma}{\gamma-1}$ which is negative and larger than 1 in absolute value. Graphically an increase in eradication shifts the supply curve upwards as shown in figure 4.3.

An increase in productivity has the opposite effect on the supply of output. Its impact is measured by the expression $\frac{\gamma}{\gamma-1}$ which is the same as the effect of eradication

except for the sign. Graphically, productivity increases lead to a downward shift in the supply curve.

There is substantial evidence that the eradication efforts in Latin American countries have been offset by increased productivity leaving the supply more of less unchanged (for evidence see Costa Storti and De Grauwe(2008)). It can be argued that much of these productivity increases have been made possible by globalization. The latter has contributed to greater access of local drug farmers to new and improved production techniques. In this sense globalization has contributed to making eradication efforts relatively ineffective.

Figure 4.1: the supply curve with different levels of eradication

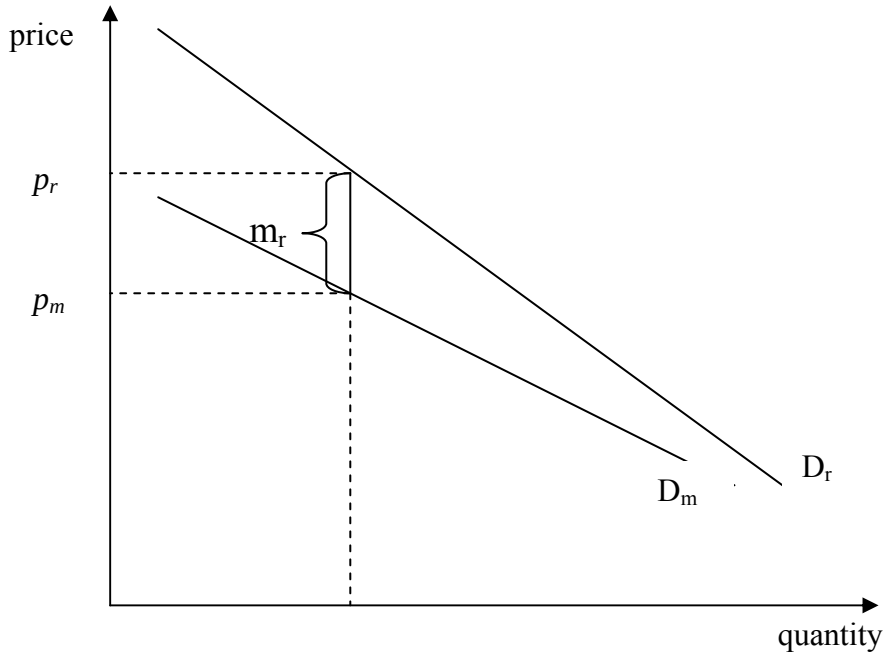


5. Linking up demand and supply of drugs

In this section we link up the retail market and the producer markets. It will be remembered that the retail market determines the retail price (and the retail added value or margin, m_r) for a given import cost of the drug. The producer market in turn determines the supply of the drug for a given export price. We can represent this graphically as follows. Figure 5.1 presents the retail market in the importing country, as we have developed it in section 3. The D_r curve represents the prices the representative drug user is willing to pay for different levels of cocaine supplied at the retail level, in the importing country.

The lower D_m curve presents the different levels of the import price, p_m, which the importer is willing to pay, given the retail price he receives in the retail market. Note that we assume here that the "upper level drug trafficker" of the retail market is also the importer[6]. The vertical distance between the two curves is the retail margin, as derived in section 3 where we modeled the retail market.

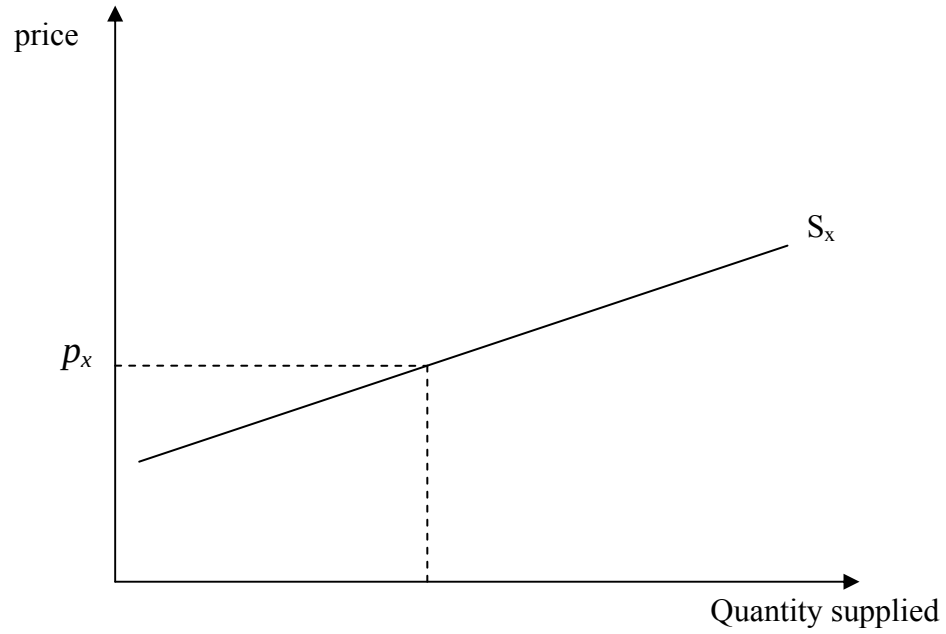
Figure 5.1: Importing country: the demand side of the model



[6] This assumption could be relaxed without affecting the results. Caulkins and Hao(2008) analyze the different distribution layers between the importer a d the retailer.

Figure 5.2 presents the producer supply equation which was derived in section 4**.** For the sake of simplicity we represent this supply curve as a linear one[7]. We assume here that the total supply is exported. Thus the price the producer is facing is the export price, p_x. An increasing export price leads producers to increase their supply.

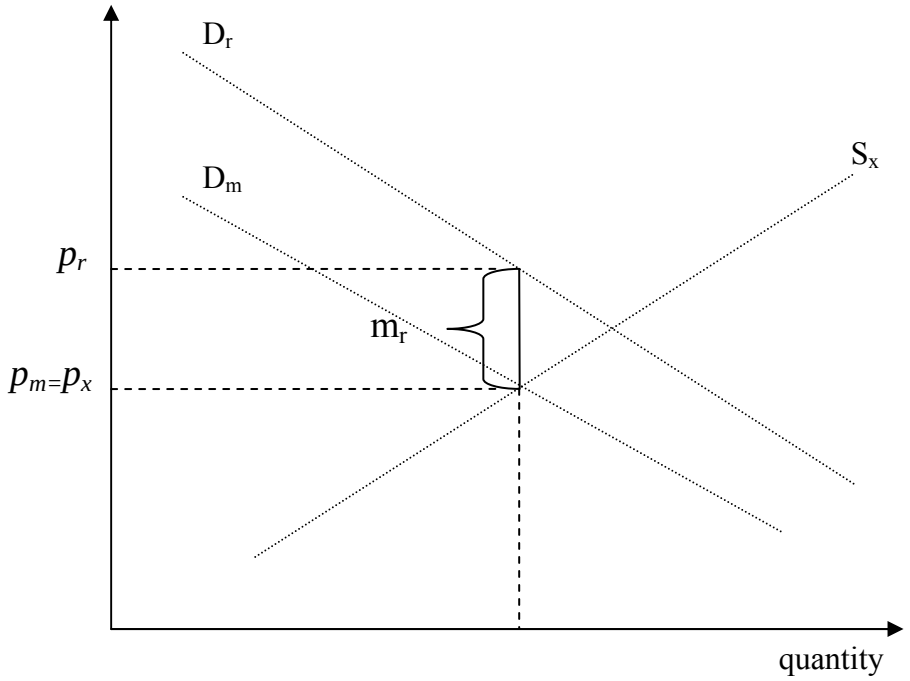
Figure 5.2: The producer country: the supply side of the model



We now bring together the demand and the supply side of the model in Figure 5.3. Without intermediation costs in the export-import business the equilibrium of the model would be obtained where the supply curve S_x intersects the import demand curve, D_m, producing a retail price p_r. In this equilibrium point, the import price of cocaine in the retail market, p_m, equals the producer's export price p_x. This is, however, highly unrealistic as the export/import of cocaine involves transaction costs and risks, introducing a margin between the import price of the drug (cif) and the export price (fob) when it leaves the producing country. The difference between these two prices is the intermediation margin in the export and import business, which we will call m_t. We model this intermediation margin in the next section. This allows us to link up the retail market determining demand conditions with the main stages of cocaine supply.

[7] In section 4 this was derived to be log-linear

Figure 5.3: equilibrium in the absence of import-export margin



5.1 A theory of intermediation in the export-import business

The components of the intermediation margin, m_t, can now be analyzed as follows. First we have to take into account that the import price in the EU or the US is expressed in euros (or dollars), while the export price paid in Andean countries is expressed in local currency. Second we have to take into consideration a margin paid to the import/export activity (m_t). Thus, we write the following definition

$$\frac{p_m}{p_x e} = 1 + m_t \qquad (5.1)$$

where, as before, p_m is the import price in the market of the final drug user. This price is expressed in that country's currency (e.g. euros or dollars); p_x is the export price in the producing country, expressed in that country's currency. Multiplying by the exchange rate, e, yields the export price expressed in the importing country's currency. The margin, m_t , includes all the costs incurred in the business of exporting and importing the drugs. This margin introduces a difference between the import price (cif) and the export price (fob) even after translating both prices in the same currency (the euro or the dollar).

The next step is to specify the variables that affect the intermediation margin m_t. We identify several cost factors that affect this margin and that therefore lead to an increase in the price, when trafficking cocaine from the producing country to the destination market.

We formalize this as follows

$$\frac{p_m}{p_x e} = (1+\tau_t)(1+\tau_s)(1+\tau_l)(1+r) \qquad (5.2)$$

where τ_t is the "plain vanilla" transport cost; τ_s is the cost of seizure; τ_l is the labour cost; and r is the profit margin in the export-import business. We now specify the different variables that affect costs.

The exchange rate

From equation (5.2) we see that a depreciation of the euro (an increase in the exchange rate, e) has the effect of either increasing the import price p_m or reducing the export price p_x, or a combination of these two changes. This follows from the fact that the variables on the right hand side of (5.2) are independent from the changes of the exchange rate. As a result, the ratio between the two prices on the left hand side of (5.2) must remain unchanged. In order to achieve this, the import price must increase and/or the export price must decline in such a way as to keep the ratio unchanged.

"Plain vanilla transport costs"

The transport cost, τ_t , is a function of the number of hours the trip from the exporting country to the importing country last (h) and its price, p_t (e.g. the introduction of low costs transatlantic flights or faster boats influence transport costs). We have

$$\tau_T = \tau_T(h, p_t) \qquad (5.3)$$

where $\frac{\partial \tau_T}{\partial h} > 0$ and $\frac{\partial \tau_T}{\partial p_t} > 0$

Seizures

Seizures add to import price in the following way. Call ρ the probability of a unit of cocaine being seized. Then shipping one dollar of the drug will lead to an expected value at arrival of 1 - ρ. Thus in order to ensure that one dollar value of drugs reaches destination, $\frac{1}{1-\rho}$ should be exported. As a result, the transport cost can be said to have increased by a factor of $\frac{1}{1-\rho}$. Thus we can write

$$1+\tau_S = \frac{1}{1-\rho} \qquad (5.4)$$

The probability of seizure, ρ, is a function of the supply reduction policies of the countries involved and the associated resources invested in supply reduction policies

$$\rho = \rho(SR), \qquad (5.5)$$

where *SR* are the resources invested in supply reduction policies.

Labour costs

The third cost component is labour cost. Let us write the wage cost per dollar of drug transported, *w*. We assume that the wage rate is determined by the reservation wage of the drug carriers (i.e. the wage they can earn in other employments) plus a risk premium. The latter arises because drug trafficking involves the risk of incarceration[8]. The higher wage above the reservation wage is the risk premium. We write that

$$w = \overline{w} + \pi_w \qquad (5.6)$$

where $\overline{w}$ is the reservation wage and π_w is the risk premium component of the wage. The latter is determined by a number of factors. First, the resources invested in supply reduction policies increase the risk of incarceration, and thus the risk premium. Second, globalization increases the pool of agents who are capable and willing to enter trafficking. This tends to reduce the risk premium. Note that we assume

[8] See Caulkins and MaccCoun (2003) for a further discussion on how this risk may affect drug dealers wage.

implicitly that the newcomers in the trafficking have a lower degree of risk aversion than those already employed in trafficking.

Formally we have

$$\pi_w = \pi_w(SR, Z) \qquad (5.7)$$

$$\text{with } \frac{\partial \pi_w}{\partial SR} > 0 \text{ and } \frac{\partial \pi_w}{\partial Z} < 0$$

Profit margins

The final component in equation (5.2) is the profit margin in the export-import business. Resources invested in the export-import business should earn a rate of return which reflects the return of alternative activities plus a risk premium. Thus we can write that

$$r = \bar{r} + \pi_r \qquad (5.8)$$

As in the case of the wage rate, the risk premium is influenced by the risk of incarceration and by the supply of new entrants in the exporting/importing business. The risk of incarceration has a positive influence on the risk premium while the supply of new entrants tends to reduce the risk premium and thus the rate of return in the exporting and importing business.

$$\pi_r = \pi_r(SR, Z) \qquad (5.9)$$

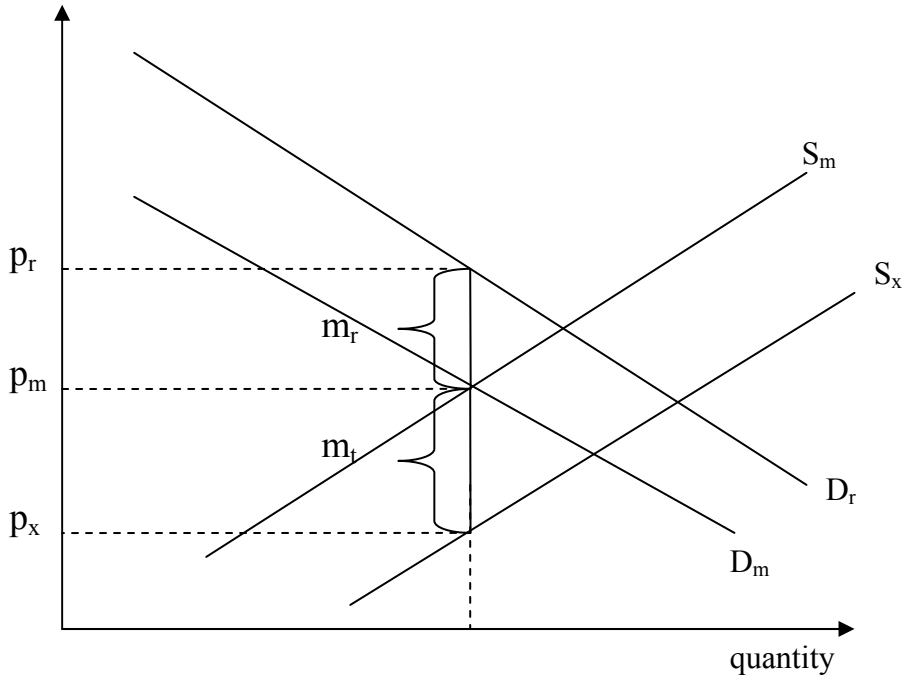
$$\text{with } \frac{\partial \pi_r}{\partial SR} > 0 \text{ and } \frac{\partial \pi_r}{\partial Z} < 0$$

Note that in a similar way as in the retail market, we implicitly assume two types of agents in the trafficking business. There are the "higher level traffickers". These are the entrepreneurs who organize the traffic and who earn the residual profits, *r*. Then there are the "lower level traffickers". They are hired by the higher level traffickers and earn the wage rate, *w*.

The equilibrium in the model is described graphically in Figure 5.4. S_x is, as before, the producer supply curve in the exporting country. S_m is the producer supply curve at

the point of import in the retail market. The vertical distance between the two lines is given by the intermediation margin, m_t. It is influenced by the different variables discussed in the previous paragraphs. Equilibrium is obtained where S_m and D_m intersect. This intersection point determines the import price in the retail market (p_m). The retail price p_r is then obtained by adding the retail margin m_r (derived in section 3). The producer price (export price) p_x is obtained by subtracting the export-import margin, m_t , derived in this section.

Figure 5.4: equilibrium with import-export margin



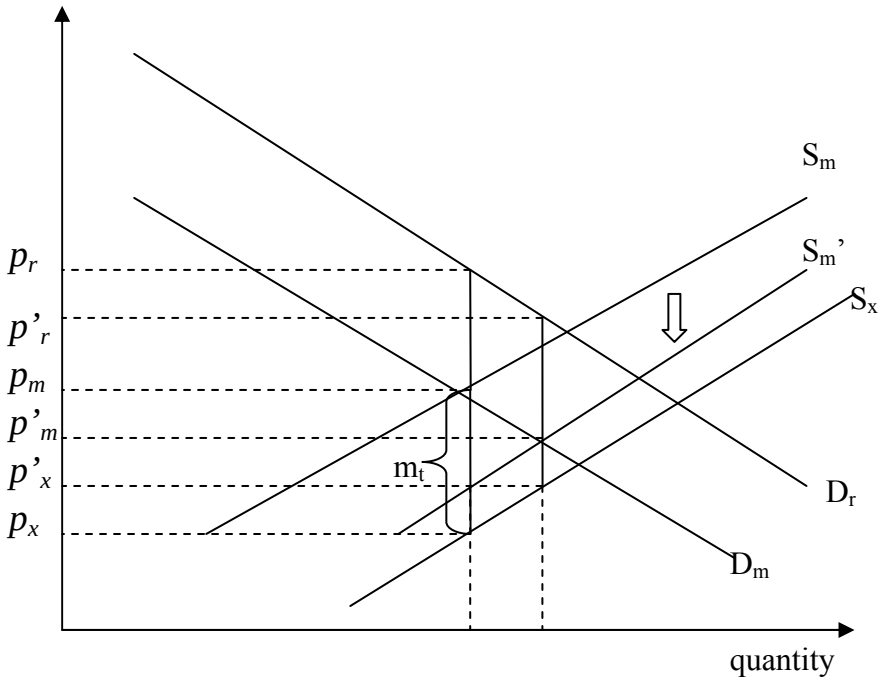
5.2 Effects of globalization

Globalization affects the risk involved in the export and import business. It does this in two ways. First, it increases the pool of low level traffickers. The opening up of countries since the 1980s has added millions of low skilled workers who have little to loose and are willing to take risks. This tends to reduce π_w, the risk premium component of the wage of the lower level traffickers in (5.6). Second, globalization also leads to entry of higher level traffickers in the export-import business which in turn leads to a lower return of these activities (equation (5.7)). The combined effect is

to reduce the margin m_t. We show the effect in figure 5.5. The reduction of the margin, m_t, shifts the import supply curve downwards to the position S'_m compared to its initial position, S_m. In the new equilibrium the import price declines to p'_m and so does the retail price (to p'_r). This is exactly what has been observed in the price data since 1980.

It is also interesting to note that the reduction of the margin m_t brought about by globalization also increases the producer price. This is shown in figure 5.5 by the increase of the producer price increases from p_x to p'_x. As was shown in section 2, producer prices have been increasing significantly in the last twenty years. Thus, our model is capable of explaining the opposite movements in retail and producer prices of cocaine. The major driving force is the reduction of the margins in the export-import business which itself was made possible by the massive influx of low and high level traffickers.

Figure 5.5: Effects of globalization



These forces of globalization appear to have overwhelmed the attempts of the authorities of the consuming countries, especially the US, to disrupt the supply of drugs. As argued earlier, the resources spent in these supply policies have increased

significantly. Our model predicts that these policies increase the intermediation margin m_t mainly because they increase the risk of trafficking. However, this effect has been more than compensated by the effects of globalization. In this sense, supply policies have been waging a loosing battle against the forces of globalization.

6. Globalization once again

In the previous sections we have analyzed the different channels through which globalization affects the markets of cocaine and heroin. In this section we put the pieces together.

We distinguish three broad effects of globalization: a market structure effect, a risk premium effect and an efficiency effect[9].

6.1 The market structure effect.

In a very general way globalization tends to open markets, thereby changing the market structure away from monopolistic towards more competitive structures. As a result, competition is enhanced and the markup, i.e. the difference between the retail price and the marginal cost is reduced. The drug market has been subject to the same forces of globalization that have changed the market structure in the drug consuming countries, increasing competition. As a result, the retail margins (markups) have been squeezed contributing to a lowering of the retail prices of drugs. We have analyzed this effect extensively in section 3 (the retail market).

6.2 The risk premium effect

Globalization has opened the borders of many countries with a surplus of poor and low skilled workers. Richard Freeman has estimated that the opening up of China, India, Russia since the 1980s has doubled the world supply of cheap and unskilled workers (Freeman(2005)). Coupled with the increased possibility of international travel, this has increased the pool of individuals who have little to use and who want to profit from the large intermediation margins in the drug business.

[9] See Costa Storti and De Grauwe(2008)

We have introduced this effect into our model in several ways. In the retail market and in the export-import business it has led to an influx of high level and low level traffickers. As a result, the risk premium component of the wage of low level traffickers has declined and the risk premium component of the return of the high level traffickers has been pushed down. The joint effect of these declining risk premia has been to reduce the intermediation margins in the cocaine and heroin markets.

6.3 The efficiency effect

Lower transport, communication and information costs have increased the efficiency of the intermediation in the drug business. In addition, lower transport costs have increased international trade in general allowing to better concealing drug trade. Finally, by opening up borders globalization has also made it possible to transfer scientific and technological knowhow.

Our model captures some these effects. In particular we have seen how the lowering of transport costs reduces the intermediation margin in the international trafficking of drugs. In addition, we have shown how increased productivity in the production of cocaine and heroin increases the supply even in an environment of tight policies of supply interdiction and eradication.

6.4 Globalization and supply containment policies

Globalization has had forceful effects in the drug market. The force of these effects can be gauged by the fact that as globalization unfolded, governments of major drug consuming countries significantly tightened policies aimed at reducing supply. These policies in isolation should have increased retail prices, reduced consumption and production. We observe that exactly the opposite occurred: retail prices declined significantly, and consumption and production continued to increase. This suggests that the forces of globalization more than offset the effects of supply containment policies. In this sense it can be concluded that these policies are waging a loosing battle against the forces of globalization.

Our model of the retail market, however, also shows that the effectiveness of supply containment can be enhanced by combining it with demand policies. The latter, if

successful, tend to increase the price sensitivity of drug users. As a result, policies that reduce the supply of drugs in the retail market and thus increase drug prices, become more effective in reducing the consumption of drugs.

8. Conclusion

Retail prices of cocaine and heroin have declined significantly during the last decades while at the same time producer prices have tended to increase. As a result, intermediation margins in the business of transporting and dealing these drugs have declined spectacularly. In addition, consumption and production of cocaine and heroin have continued to increase. These are puzzling developments because at the same time efforts to limit the supply of drugs by law enforcement methods (seizures, incarceration) have intensified. These supply containments policies should have increased retail prices, increased intermediation margins, reduced consumption and production. The opposite occurred. We argued in this paper that this has happened because the forces of globalization have overwhelmed the supply containment policies.

In order to understand these developments better we developed a theoretical model of the cocaine and heroin markets. The model consists of three parts, a retail market determining the demand side, a producer supply process and an international part describing the export-import business.

The main novelty of the analysis is to model the retail market as a market characterized by monopolistic competition. This is a market form often analyzed in economics. We consider the upper level dealers to have some market power allowing them to charge a markup and thus to earn extra profits. This is the "monopolistic" part. At the same time this extra profit attracts newcomers in the business so that these profits tend to disappear. This is the "competition" part in the model.

We used this model to analyze how supply containment policies affect the retail market, the producer market and the export-import business. In general, law enforcement measures (e.g. incarceration) increase the risk premia that have to be obtained both by the lower and higher level traffickers in order to engage in drug dealing.

Much of our analysis was focused on modeling the different ways globalization affects the drug markets. We distinguished between a market structure effect, a risk premium effect and an efficiency effect of globalization.

We found that in general globalization has the opposite effects of supply containment policies. It lowers intermediation margins and as a result tends to lower retail prices, thereby stimulating consumption. At the same time it increases the prices obtained by the producers, tending to increase production. In so doing, globalization offsets the effects of supply containment policies. Since retail prices have declined, producer prices have increased and production and consumption have increased, one should conclude that globalization has overwhelmed the effects of supply policies.

Finally, using the model of the retail market, we showed that the effectiveness of supply containment policies can be enhanced by combining them with demand policies. The latter, if successful, tend to increase the price sensitivity of drug users. This is so because demand policies create alternatives for drug users in the form of treatment. As a result, policies that reduce the supply of drugs in the retail market become more effective in reducing the consumption of drugs because they operate in an environment in which consumers react more strongly to price increases.

References

Abt Associates, (2000), Illicit Drugs: Price Elasticity of Demand and Supply, Report Prepared for the National Institute of Justice, Cambridge.

Basov, S., Jacobson, M., Miron, J., (2001), Prohibition and the Market for Illegal Drugs – an Overview of Recent History, *World Economics*, vol 2, no. 4, October-December.

Bretteville-Jensen A. L. Biorns E. (2004), Do prices count? A micro-econometric study of illicit drug consumption base on self-reported data, Empirical Economics, Spring 2004, 29:673-695, June 2004

Caulkins, J.P. (1996), Estimating elasticities of demand for cocaine and heroin with DUF data. Pittsburgh: Working Paper, Heinz School of Public Policy, Carnegie Mellon University.

Caulkins J., Peter R. (1998), "What Price data tell us about drug markets" in Journal of Drug Issues: Summer 98, Volume 28, Issues 3: 593-613, Summer 1998.

Caulkins J. (2001), "Drug Prices and Emergency Department Mentions for Cocaine and Heroin", American Journal of Public Health, Vol 91, 9:1446-1448.

Caulkins J., MacCoun R. (2003): "Limited rationality and the Limits of Supply Reduction", in JSP/ Centre for the Study of Law and Society Faculty, University of California, Berkeley.

Chaloupka F., Saffer H. (1995) "The Demand for Illicit Drugs" in Economic Inquiry 1999,
Vol 37; No. 3:401-411.

Chamberlin, E., 1936, *The Theory of Monopolistic Competition: A Reorientation of the Theory of Value*. Cambridge: Harvard University Press.

Dave, D., (2004), The Effects of Cocaine and Heroin Prices on Drug-Related Emergency Department Visits, NBER Working Paper, no. 10619, July.

Dixit, A., Stiglitz, J. (1977), Monopolistic Competition and Optimum Product Diversity, *American Economic Review*, 67:3, 297-308, June.

Feenstra, R., 2004, *Advanced International Trade. Theory and Evidence*, Princeton University Press, 484 pp.

Freeman, F., (2005), What Really Ails Europe (and America): The Doubling of the Global Workforce, the Globalist Paper, June.

Grossman, Michael (2004). "Individual Behaviors and Substance Abuse: The Role of Price," NBER Working Paper No. 10948.

Helpman, E., and Krugman, P., 1985, *Market Structure and Foreign Trade*, Cambridge, MIT Press. 271 pp.

Matrix Knowledge Group (2007), The Illicit Drug Trade in the United Kingdom, Home Office Report 20/7

Kennedy M., Reuter P. Riley K.J. (1993), A Single Economic Model of Cocaine Production, Mathematical Computing Modelling, Vol. 17, 2:19-36.

Krugman, P., 1979, Increasing Returns, Monopolistic Competition, and International Trade, *Journal of International Economics*, 9:469-79.

Robinson, J., 1933, *The Economics of Imperfect Competition*, London: Macmillan

Reuter, P., and Kleiman, M., (1986), Risks and Prices: An Economic Analysis of Drug Enforcement, *Crime and Justice*, Vol. 7, pp. 289-340

Reuter, P., (2001), The Limits of Supply-side Drug Control, The Milken Institute Review, First Quarter, pp. 14-23.

Singleton N., Murray R., Tinsley L. (2006), Measuring Different aspects of Problem drug use: methodological Developments, Home Office Online Report 16/06.