Diffusion of counterfeit medical products in a developing country: Empirical evidence for Suriname

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Abstract

Based on detailed shipping figures of Suriname's main harbour in Paramaribo, we estimate the total shipments (in kilograms) of original and counterfeit medical products for 1996-2008 across five product categories. Using various time series techniques, we document that total cumulative shipments of counterfeit products eventually will make about 40% of total shipments. Correlation between the shipment series is on average 0.9, and there are no relevant leads or lags, implying that there are two distinct sets of consumers for original and for counterfeit products.

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> *"The World Health Organization (WHO) estimates that up to 1% of medicines available in the developed world is likely to be counterfeited. This figure rises to 10% globally, although in some developing countries they estimate one third of medicines are counterfeit*"
> (Various internet sites consulted January 2010)

1. Introduction

The diffusion of pharmaceutical products has received some attention in the recent marketing literature; see for example Staake et al. (2009). It has been documented that the diffusion patterns show various similarities with the diffusion patterns of durable consumer goods, see for example Desiraju et al. (2004). As pharmaceutical products may experience the impact of regulatory regimes, diffusion patterns may change direction and slope due to these regimes, see for example Stremersch and Lemmens (2009). In all studies available, there is a strong focus on the diffusion patterns in western countries, usually driven by data availability, although Desiraju et al. (2004) also include data for various developing countries. A common assumption across all studies is that the focus is on the producer of the pharmaceutical products, usually US or European companies.

In this paper we also address the diffusion patterns of pharmaceutical products where we relegate the focus on the actual shipments of such products in a developing country. This change of focus then naturally has to include the fact that in developing countries many pharmaceutical products are counterfeits. The exact amount of these counterfeit drugs is unknown, and therefore we will provide a method to estimate the fraction of counterfeit products within a single developing country.

Exact data on counterfeit drugs are usually not available, and certainly not in a developing country. One way to estimate the size of the counterfeit market is to try to disentangle the counterfeit diffusion from the total diffusion, as is proposed in Givon et al. (1995) for software products. An alternative would be to estimate it directly from the shipments data, if these would be available, see for example Franses and Lede (2010).

The focus in the present paper is the diffusion of original and counterfeit medical products in the South American country Suriname. Based on detailed data on shipments of products in five distinct categories, we estimate the diffusion of original and counterfeit products for the sample from 1996 to 2008. With these data, we can analyze the correlations between the two diffusion patterns. Also, we examine the lead and lag structure across original and counterfeit products. Finally, we estimate the total cumulative shipments using the familiar Bass model, and we compare the eventual maturity levels for each of the categories. So, in contrast to what the WHO documents, we provide estimates of the total amount that *in the end* will have found its way to consumers. We are not interested in the actual figures, but merely in the fraction of counterfeit in the total amount.

The main finding in this paper is that counterfeit drugs and other medical products eventually make around 40% of the total shipments in this particular country of Suriname. Note that this fraction exceeds the estimates of the WHO. A second finding is that the two diffusion processes are correlated contemporaneously, reacting similarly to the same outside shocks, but that there is no significant lead or lag relationship. This suggests that the original and counterfeit products each address a distinct segment of the market.

The outline of the paper is as follows. First, in section 2 we describe the data collection and the creation of the two series for original and for counterfeit products. In Section 3 we analyze the data using basic time series techniques and using familiar diffusion models. Section 4 concludes with a discussion of the main findings and their implications.

2. Data collection

We have collected data for the South American country of Suriname. It is a small and open economy, with a single large (maritime) harbour in the capital city of Paramaribo. The country has many natural resources. It used to be a colony of the Netherlands, before it became independent in 1975. Economic growth slowed down since the beginning of the 1980s, but since 2000 there is a steady growth in GDP and an increase in welfare. The country is sparsely populated, with most of the citizens living in the coastal area. Although average welfare is on the rise, the income

inequalities in Suriname are quite large. The country boasts a non-negligible group of multi-millionaires, but on the other hand it is estimated that more than 60% of the population is below international poverty levels.

Sales records for medical products do not exist. Hence, we have to estimate the diffusion patterns of these products using alternative methods. We consulted Statistics Suriname and we were able to collect annual data on the imports of products in five categories for the period 1996 to and including 2008. The product categories are Pharmaceutical items, Medicine, for sale small scale, Medicine, not for sale small scale, Wound-covering materials and Blood items. These imports are measured in kilograms and in total value (in US dollars). We decided to take the weights as the measurement unit to avoid correction for inflation in the exporting countries. Crucial for our purposes is that we have information on the countries of origin of the shipments. In Appendix A, we give the countries of origin, and we indicate from which countries which products in the five categories, originate. Clearly, Suriname imports from a long list of countries, and there is also variation across the categories.

To estimate the shipments of original products and counterfeit products, we use the software piracy index, which can be obtained from www.nationmaster.com. This website presents a list of countries and gives an estimate of the fraction of products (here: computer software) that are most likely counterfeit. In Appendix B we provide a list of relevant countries for our product categories and the corresponding percentages. Like this list, we shall take it as likely that 23% of the pharmaceutical products that are imported from Japan amount to counterfeit products, and that it is as much as 82% of these products originating from China that are counterfeits. Of course, we shall never be certain whether these percentages also hold for our product categories, nor if this figure changes over time or amounts to a biased estimate, and hence the subsequent data should not be considered as exact amounts, but merely as estimates. That is, the absolute numbers do not matter, but their time series properties do. In order to allow the reader to verify the computations about which we report in the next section, we present our data in Appendix C. Graphical details and other aspects of these series will be discussed in the next section.

3. Analysis of shipments data

This section deals with the statistical analysis of the two diffusion series. We analyze the levels of the shipments, as in Appendix C, and the cumulated shipments. The latter are used to estimate the eventual total size of the market. The first pairs of series are analyzed to see if there are leading or lagging diffusion processes amongst the two series. We discuss the methodology, first for cumulative shipments and then for shipments themselves, and we discuss the results in each of the five categories.

Methodology for cumulative shipments

We denote the level of the original products shipments as O_t and the level of the shipments of counterfeits as C_t where $t = 1996,1997,...,2008$. The data appear in the Appendix C. We also compute the cumulative shipments, and label these as CO_t and CC_t. Graphs of the series for the five categories appear in Figures 1 to 5. The second panel of each of these Figures suggests that the cumulative shipments obey a product life cycle that can also be observed in the diffusion of durable products. Hence, the first part of our methodology involves considering diffusion models to estimate the inflection points and the ultimate maturity levels of these cumulative series.

Insert Figures 1 to 5 about here

For the CO_t and CC_t variables, we consider the familiar Bass model (Bass, 1969), which in our notation can be written in regression format as

(1) $$O_t = p_o m_o + (q_o - p_o)CO_{t-1} - \frac{q_o}{m_o} CO_{t-1}^2 + \varepsilon_t$$

and

(2) $$C_t = p_c m_c + (q_c - p_c)CC_{t-1} - \frac{q_c}{m_c} CC_{t-1}^2 + v_t$$

for originals and counterfeits, respectively. The parameters p and q characterize the shape of the diffusion pattern, and determine the location of the inflection point I which can be calculated as

$$I = \frac{1}{p+q}\log(\tfrac{q}{p}) \tag{3}$$

The parameters in the Bass model may be difficult to estimate in case the data do not yet include the inflection point. If this happens, we replace the Bass model by the symmetric logistic curve, given by

$$OC_t = \frac{m_o}{1+\exp(-\gamma_o(t-I_o))} \tag{4}$$

and

$$CC_t = \frac{m_c}{1+\exp(-\gamma_c(t-I_c))} \tag{5}$$

for originals and counterfeits, respectively. Here the parameter γ characterizes the shape of the curve, and again I corresponds with the timing of the inflection point. Due to the imposed symmetric nature of the logistic curve, one can still adequately estimate the location of the inflection point, even when it is not included in the sample. The estimation routine is Nonlinear Least Squares. In both cases, that is the Bass model and the logistic curve, our interest lies in the parameters m, the ultimate level of total shipments, and I, the location of the inflection point.

Insert Table 1 about here

In Table 1 we present the present the estimates of the maturity level. We also compute the fraction of m_c over $m_o + m_c$. As said, this latter fraction is most relevant for our purposes. Table 1 suggests that it can range from about 0.3 to 0.5, with an

average close to 0.4. In words, about 40% of the eventual total shipments in medical products in Suriname concerns counterfeit products. It is interesting to see that the variation of the estimate of the fraction across the five product categories is quite small.

Insert Table 2 about here

Table 2 gives the estimates of the inflection points. For two of the five categories the years with these points coincide. For Medicine, not for sale small scale, the inflection point of counterfeits occurred earlier, suggesting that the maturity level for this series is attained earlier than for the original products. For two categories the counterfeit series peak later, with for Blood Items meaning that in the next few years still a substantial amount of counterfeit products will be imported in Suriname, at least, if the current situations persists.

Methodology for shipments

The graphs in Figures 1 to 5 seem to suggest that shipments of original and of counterfeit products show similar diffusion patterns. It is of interest to see if one of the two series is leading (or lagging). Indeed, in Franses and Lede (2010) it was documented that original products' diffusions lead that of counterfeits.

To examine leads and lags relations, we estimate a vector autoregression of order 1 (VAR(1)), which consists of the following two equations

(6) $$O_t = \mu_1 + \beta_1 C_t + \rho_1 O_{t-1} + \delta_1 C_{t-1} + \varepsilon_t$$

and

(7) $$C_t = \mu_2 + \beta_2 O_t + \rho_2 O_{t-1} + \delta_2 C_{t-1} + \nu_t$$

Note that a genuine VAR(1) model would not include current C_t and O_t, but here it allows for a partial correction for current effects. The test of interest concerns the joint significance of ρ_1, δ_1 in (6) and of ρ_2, δ_2 in (7).

Insert Table 3 about here

In Table 3 we present the p values of the F tests. Except for the category Medicine, not for sale small scale, we find that these parameters are not significantly different from zero. For the exceptional category, we learn that lagged shipments of originals leads current shipments of originals. So, in sum, there is no leading or lagging variable across originals and counterfeits.

Insert Table 4 about here

Table 4 gives the contemporaneous correlation between the two series, and it is quite evident that this correlation is high.

In sum, we find that original and counterfeit medical products follow similar diffusion patterns and that no series is leading or lagging the other. When it is assumed that all individuals in Suriname are equally likely to need medical products, our findings suggest that the shipments address two distinct segments of consumers. There is demand for original products and there is demand for counterfeit products, with the demand for originals in the end being 1.5 times as large as demand for counterfeits, as the fraction of counterfeits in the total shipments is 40%.

4. Conclusion

In addition to the available global estimates of the WHO, we provide detailed estimates of shipments of original and counterfeit medical products in the South American country of Suriname. The numbers of these estimates are not particularly relevant, as we are interested in the relative numbers and the current and dynamic correlations across the two series. When we analyze the diffusion patterns, we see that total shipments (to be observed many years from now) will cover about 40% counterfeits. Moreover, we see that current correlation is high, and that there are no relevant leads or lags. Hence, the two types of shipments seem to address two distinct clusters of consumers.

In Franses and Lede (2010) it was documented that for shipments of durable products like televisions, mobile phones and DVDs slightly different results appeared, but the notion of having two clusters of consumers was also addressed in that study. A

first and immediate conclusion that one could draw is that original products would find their way to a richer set of consumers, while the counterfeit products would be targeted at the poorer part of the country. This conclusion could be plausible at first sight, but needs much more refined analysis. This conclusion would assume that all consumers are similarly in need for medical products. It could however very well be that poorer inhabitants of Suriname are less often ill than richer inhabitants are. Similarly, why would poorer individuals have the same demand for products like DVDs and for certain specific medical products? More research on this issue is clearly needed.

5. Policy implications

For Suriname we emphasize that the battle against counterfeit pharmaceutical products is one that asks much effort on the part of the Surinamese government. As a member of the WHO, this country needs to make greater effort to adopt the WHO schemes and to make more use of the information, instructions, and opportunities presented by this organization's global coalition of stakeholders, that is, the International Medical Products Anti-Counterfeiting Taskforce (IMPACT). The Surinamese government needs to tighten the relevant legislation and regulations so that substantial fines and even more appropriate prison sentences can be declared against those persons and organizations who engage in the import and sale of counterfeit pharmaceuticals.

Furthermore, the Surinamese government needs to raise the awareness of the citizens. The majority of the citizens have no background information on the pharmaceutical products they use, let alone on how to detect counterfeit versions among the original pharmaceuticals. Of course, not all original pharmaceuticals are as simple to distinguish from counterfeits, as others. However, there are counterfeit pharmaceuticals which people can detect with little effort. Government must take the leading role in empowering the citizens by adequately informing them about how to determine the originality of pharmaceuticals. Surinamese government must also inform the inhabitants about the fatal consequences of counterfeit versions of pharmaceutical products, and thus the great health risks these products may inflict on those who use them. This tightening of the government's policy in the battle against counterfeit pharmaceuticals is very likely to result in a significant reduction of the

trade in these products in Suriname, and hence reduce the risk of exposure to the dangers of these products. Moreover, not only legislation and regulation policy needs to be tightened, but also the policy regarding control and the effective implementation thereof, needs to be taken into account.

Additional to the Surinamese government, there are at least three stakeholders that can also play a role in this battle. The first stakeholder is customs. Since it is suspected that large portions of counterfeit pharmaceuticals are smuggled into the country, this stakeholder will need to improve its control concerning the import of these products. Stricter control, combined with tight legislation and regulation will enable the custom officials to increasingly contribute to reducing the import of and the trade in counterfeit pharmaceuticals.

The second stakeholder, that is, the Pharmaceutical Inspection, the control mechanism of the Surinamese government with regard to the pharmaceutical products, is responsible to inspect and control the pharmaceutical market. This department is supported by the Office for Pharmaceutical Supply in Suriname. The latter focuses on the quality controls of locally produced and imported drugs. The Pharmaceutical Inspection, small in size, may lack the capability to optimally inspect and control the pharmaceutical business in Suriname. We suggest that the government increases its support to these organizations.

The final stakeholder is the consumer. As the citizens (but also hospitals and similar institutions) ultimately determine the extent to which the sale of products increase or decrease, this stakeholder also needs to participate in reducing the trade in counterfeit pharmaceuticals in Suriname. Of course, before customers are able to consciously choose to purchase and use original pharmaceutical products, first and foremost they will need to be adequately informed about the disadvantages of counterfeit pharmaceuticals. Furthermore, they will need to be informed about how to detect the counterfeit pharmaceuticals from the original versions.

Appendix A: Import from countries

	Product Category				
	A	B	C	D	E
Countries					
Antigua			x	x	
Dutch Antilles	x		x	x	x
Aruba				x	
Australia	x		x		
Austria			x	x	
Bahamas	x				
Barbados	x	x	x		
Belgium	x	x	x	x	x
Brazil	x	x	x		x
Canada	x	x	x	x	x
China	x	x	x	x	x
Colombia	x		x	x	
Costa Rica	x		x		
Cyprus	x		x		
Denmark	x		x		x
Egypt			x		
El Salvador			x		
United Emirates				x	
French Guyana	x	x		x	x
France	x	x	x	x	x
Germany	x	x	x	x	
Greece			x		
Guatemala	x		x		
Guyana	x		x	x	
Hungary					x
India		x	x	x	
Indonesia		x	x	x	
Israel			x		
Ireland	x	x			
Italy					x
Jamaica	x				x
Japan	x		x	x	
South Korea	x	x	x	x	x
St Lucia	x				
Mexico			x		x
Namibia	x				
Netherlands	x	x	x	x	x
New Zealand			x		x
Niger	x				
Norway					x
Panama	x	x	x	x	
Portugal	x			x	
Puerto Rico	x	x	x	x	
Russia			x		

Appendix A (Continued): Import from countries

San Marino			x		
South Africa	x				
Spain	x				
Sweden	x		x		
Switzerland	x	x		x	x
Taiwan			x	x	
Thailand		x	x	x	x
Trinidad and Tobago	x	x	x	x	
United Kingdom	x	x	x	x	
United States	x	x	x	x	x
Venezuela	x				

(A) Pharmaceutical items, (B) Medicine, for sale small scale, (C) Medicine, not for sale small scale, (D) Wound covering materials and (E) Blood items

Appendix B: Percentage of products that is counterfeit (based on the software piracy rate, www.nationmaster.com, consulted December 2009)

Antigua	50	Dutch Antilles	50
Aruba	50	Australia	28
Austria	25	Bahamas	50
Barbados	50	Belgium	25
Brazil	59	Canada	33
China	82	Colombia	58
Costa Rica	61	Cyprus	50
Denmark	25	Egypt	60
El Salvador	81	United Emirates	35
French Guyana	42	France	42
Germany	27	Greece	58
Guatemala	80	Guyana	50
Hungary	42	India	69
Indonesia	84	Israel	32
Ireland	34	Italy	49
Jamaica	50	Japan	23
South Korea	43	St Lucia	50
Mexico	61	Namibia	50
Netherlands	28	New Zealand	22
Niger	50	Norway	29
Panama	74	Portugal	43
Puerto Rico	44	Russia	73
San Marino	50	South Africa	34
Spain	43	Sweden	25
Switzerland	25	Taiwan	40
Thailand	78	Trinidad and Tobago	50
United Kingdom	26	United States	20
Venezuela	87		

Note: When a country does not appear on the list, we use the score 50.

Appendix C: The data

Table C1: Shipments of original and counterfeit products: Pharmaceutical items, general (in kilograms)

Year	Original	Counterfeit
1996	6984.570	2437.430
1997	6726.670	2404.330
1998	52109.53	19346.47
1999	79784.10	29644.90
2000	102338.1	40856.93
2001	22542.07	8584.930
2002	75868.91	20278.09
2003	12747.33	5462.670
2004	12117.31	7397.690
2005	8025.620	2938.380
2006	8639.090	3554.910
2007	15909.47	6238.530
2008	15565.72	10033.28

Table C2: Shipments of original and counterfeit products: Medicine, for sale small scale (in kilograms)

Year	Original	Counterfeit
1996	7140.120	3402.880
1997	3721.980	1606.020
1998	1631.590	673.4100
1999	2360.470	818.5300
2000	25662.14	9946.860
2001	55775.76	16261.24
2002	27512.91	9549.090
2003	22004.05	7445.950
2004	16083.69	6314.310
2005	30502.89	17907.11
2006	43727.94	24332.06
2007	120884.8	164090.2
2008	56326.23	32061.77

Table C3: Shipments of original and counterfeit products: Medicine, not for sale small scale (in kilograms)

Year	Original	Counterfeit
1996	82410.42	34027.58
1997	126437.3	53107.74
1998	87937.55	42676.45
1999	66519.33	45686.67
2000	129504.3	70367.69
2001	91668.09	48919.91
2002	88133.77	42033.23
2003	237083.1	105841.9
2004	176400.2	101030.8
2005	413139.4	479416.6
2006	284124.9	200984.2
2007	278071.7	127044.3
2008	302822.2	141556.8

Table C4: Shipments of original and counterfeit products: Wound covering materials (in kilograms)

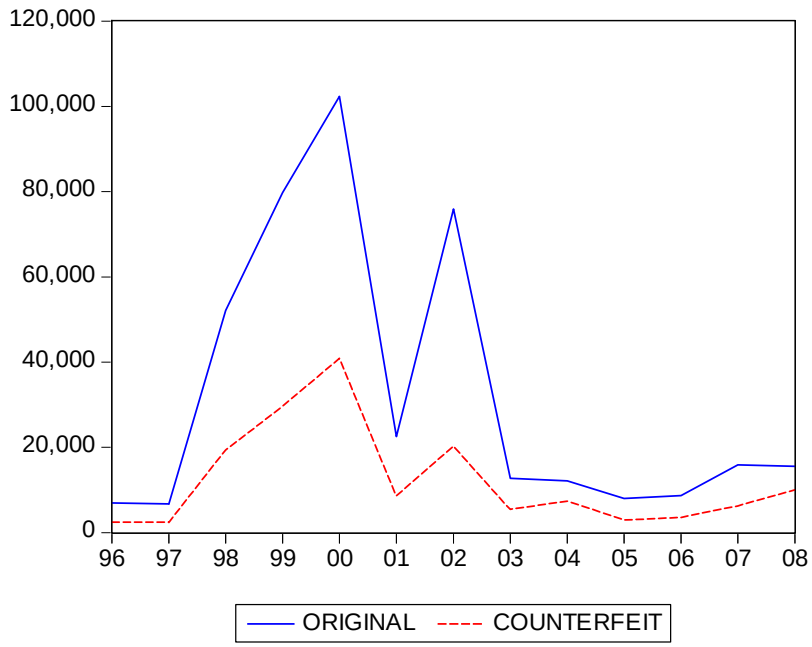
Year	Original	Counterfeit
1996	21680.89	11375.11
1997	25731.19	26771.81
1998	18485.60	8128.400
1999	10025.28	6677.720
2000	23374.10	10868.90
2001	28716.47	17209.53
2002	20663.89	14954.11
2003	45351.56	23804.44
2004	48713.34	23512.66
2005	33667.00	16122.00
2006	44422.59	22254.41
2007	33909.00	21029.00
2008	52893.00	38540.00

Table C5: Shipments of original and counterfeit products: Blood items (in kilograms)

Year	Original	Counterfeit
1996	1007.850	364.1500
1997	12778.71	11796.29
1998	6391.800	2106.200
1999	2160.360	838.6400
2000	3251.140	1259.860
2001	3112.780	1131.220
2002	731.4600	370.5400
2003	5704.680	3990.320
2004	16571.03	6558.970
2005	8564.730	3352.270
2006	1759.190	777.8100
2007	2634.270	1126.730
2008	45435.90	17764.10

Figure 1: Shipments and cumulative shipments of original and counterfeit products:

Pharmaceutical items



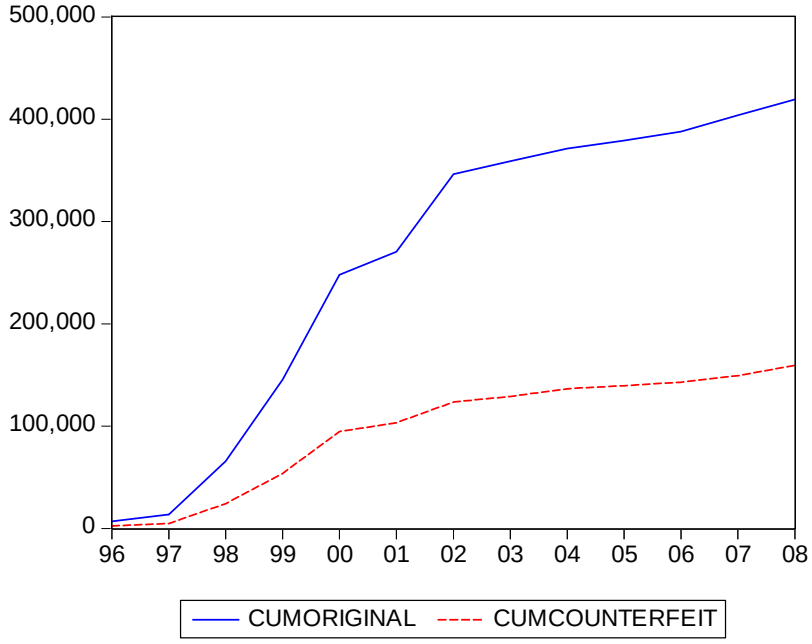
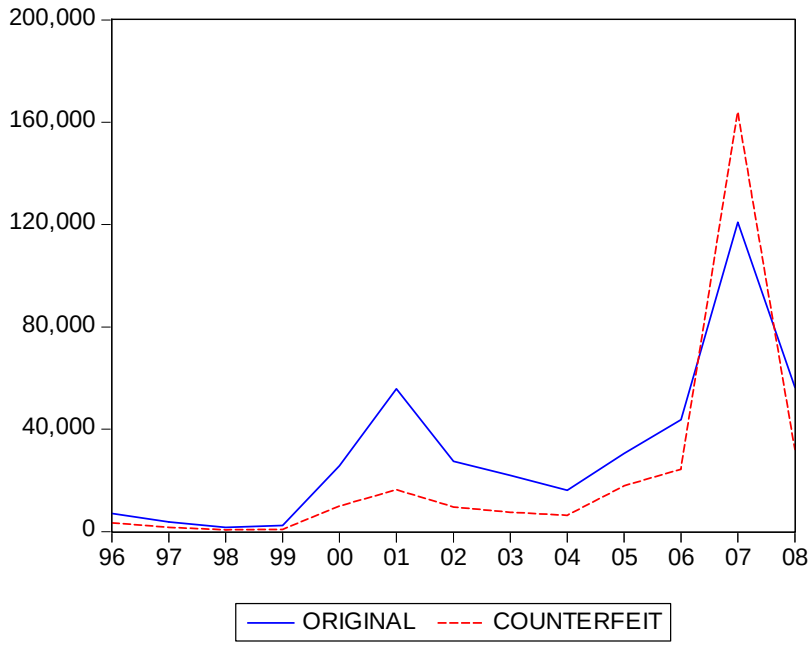


Figure 2: Shipments and cumulative shipments of original and counterfeit products:

Medicine, for sale small scale



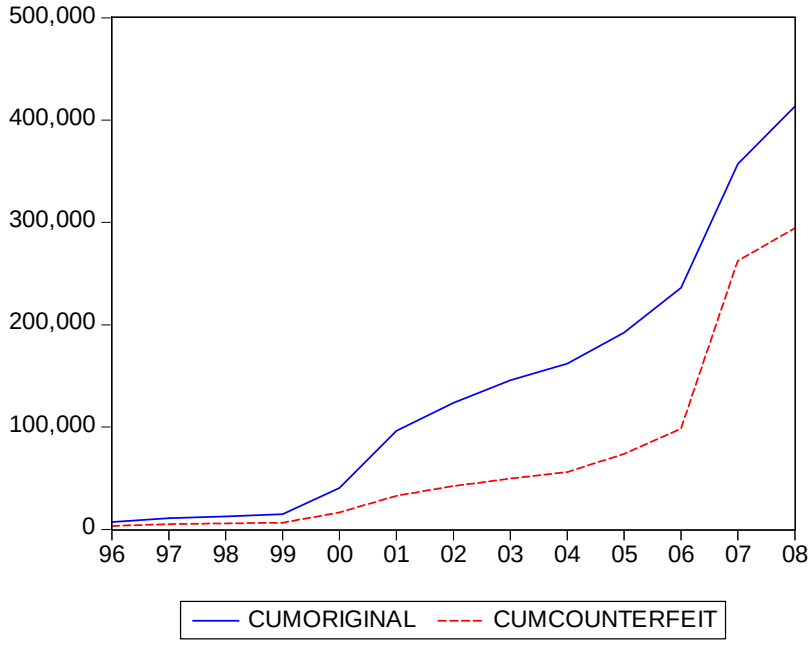
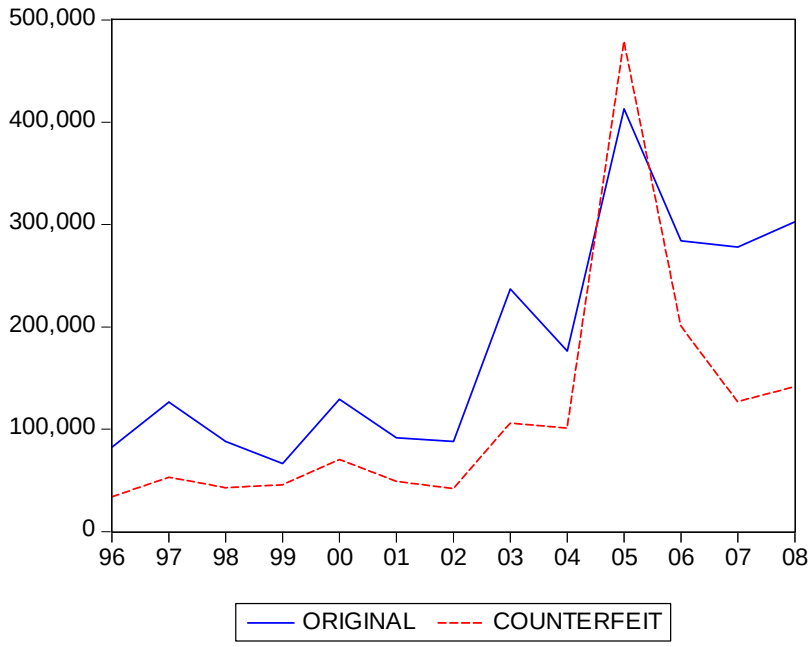


Figure 3: Shipments and cumulative shipments of original and counterfeit products:

Medicine, not for sale small scale



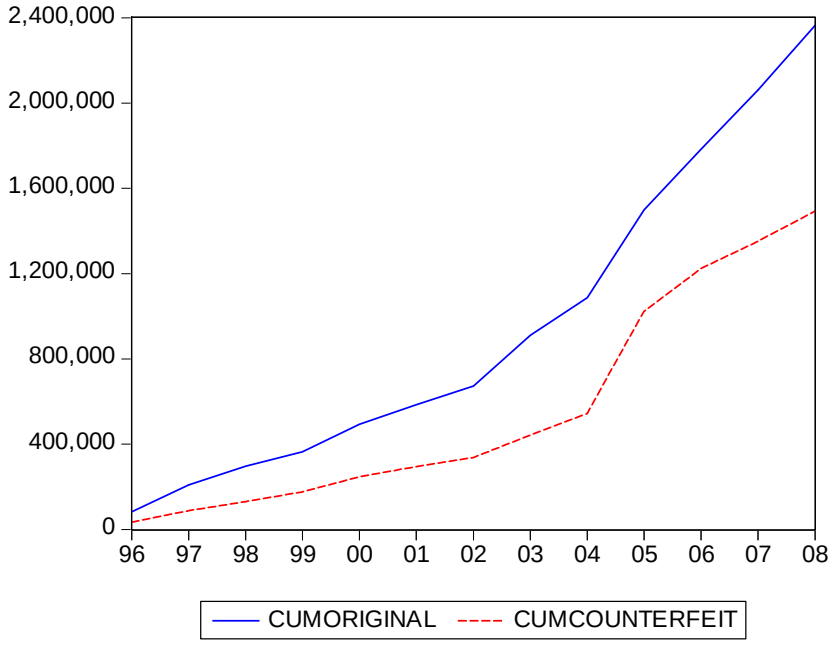
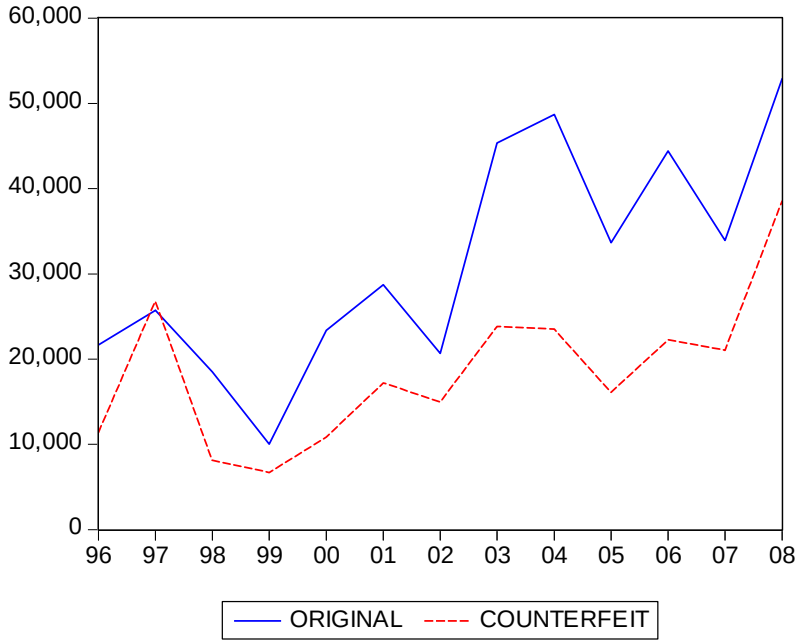


Figure 4: Shipments and cumulative shipments of original and counterfeit products:

Wound covering materials



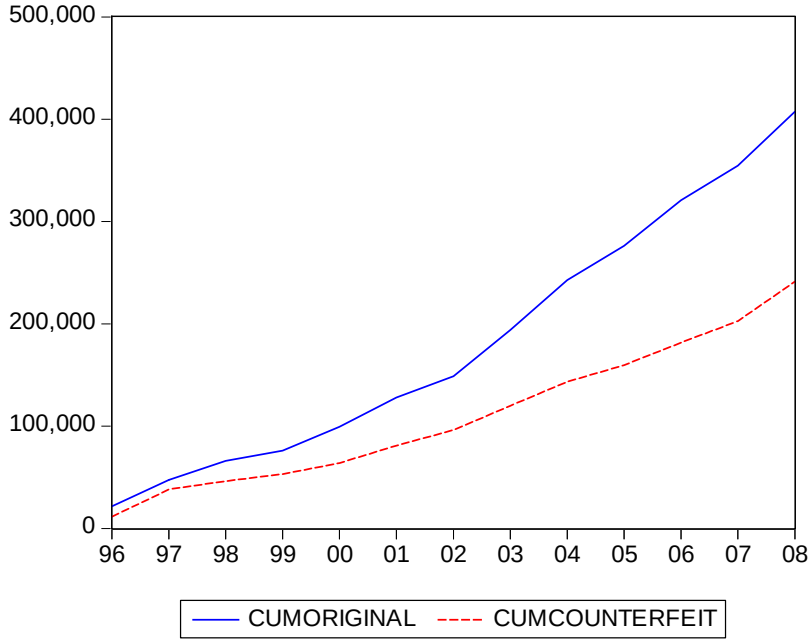
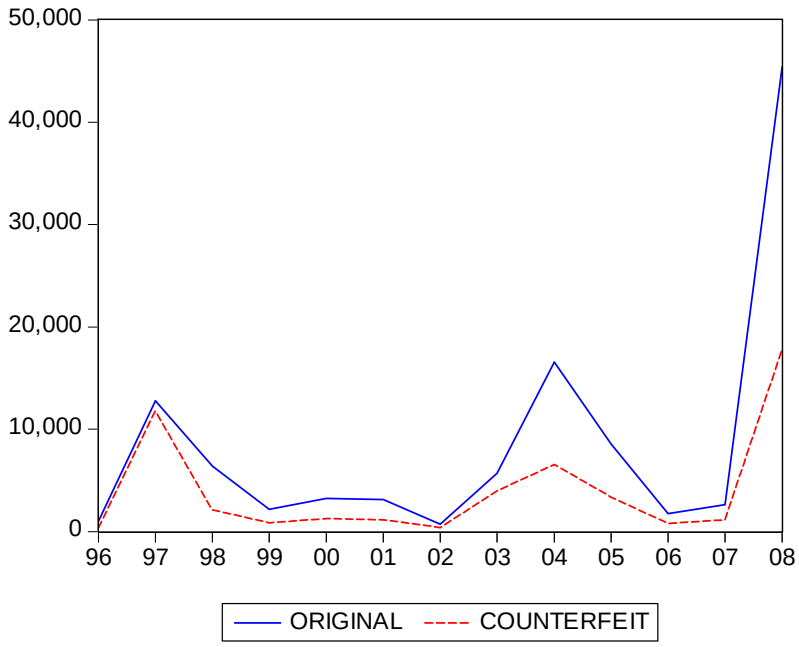


Figure 5: Shipments and cumulative shipments of original and counterfeit products:

Blood items



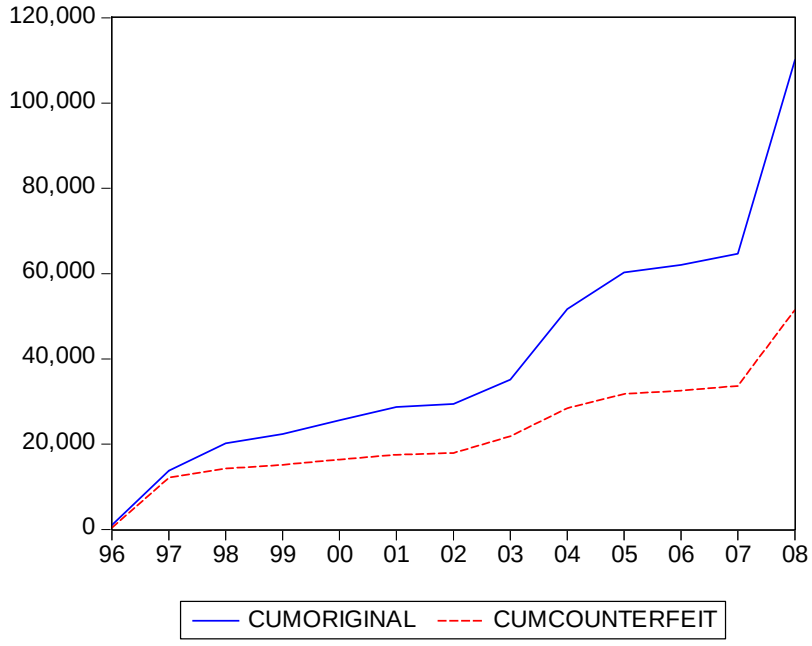


Table 1:

Fraction of counterfeit shipments over total shipments, based on estimates of the eventual maturity level

Variable		Estimated Maturity Level		
		Original	Counterfeit	Fraction
(A)	Pharmaceutical items	396066	148209	0.272
(B)	Medicine, for sale small scale	1283915	1262614	0.496
(C)	Medicine, not for sale small scale	4463491	2128846	0.323
(D)	Wound-covering materials	582769	386618	0.399
(E)	Blood items	372778	267351	0.418
Average				0.382

Note: The Bass model is used for (A), while the logistic model is used for (B), (C), (D) and (E).

Table 2:

Estimated inflection points for original and counterfeit shipments

Variable		Estimated Inflection Point	
		Original	Counterfeit
(A)	Pharmaceutical items	1999	1999
(B)	Medicine, for sale small scale	2010	2010
(C)	Medicine, not for sale small scale	2008	2006
(D)	Wound-covering materials	2005	2006
(E)	Blood items	2013	2018

Note: The Bass model is used for (A), while the logistic model is used for (B), (C), (D) and (E).

Table 3:

P-values of the F-test for the joint relevance of one-year lagged shipments of original products and one-year lagged shipments of counterfeit products (Each equation contains an intercept and current sales of the other variable)

	Dependent variable	
	Original	Counterfeit
Variable		
Pharmaceutical items	0.933	0.806
Medicine, for sale small scale	0.119	0.382
Medicine, not for sale small scale	***0.038***	0.325
Wound covering materials	0.389	0.840
Blood items	0.653	0.529

Table 4:

Correlation between shipments of original products and of counterfeit products

Variable	
Pharmaceutical items	0.973
Medicine, for sale small scale	0.914
Medicine, not for sale small scale	0.871
Wound covering materials	0.835
Blood items	0.932
Average	0.905

References

Bass, Frank M. (1969), A new product growth model for consumer durables, *Management Science*, 15, 215–227

Desiraju, Ramarao, Harikesh Nair, and Pradeep Chintagunta (2004), Diffusion of new pharmaceutical drugs in developing and developed nations, *International Journal of Research in Marketing*, 21, 341-357.

Franses, Philip Hans and Madesta Lede (2010), Diffusion of original and counterfeit products in a developing country, Econometric Institute Report 2010-08, Erasmus School of Economics.

Givon, Moshe, Vijay Mahajan and Eitan Muller (1995), Software piracy: Estimation of lost sales and the impact of software diffusion, *Journal of Marketing*, 59, 29-37

Staake, Thorsten, Frederic Thiesse, and Elgar Fleisch (2009), The emergence of counterfeit trade: A literature review, *European Journal of Marketing*, 43, 320-349

Stremersch, Stefan and Aurelie Lemmens (2009), Sales growth of new pharmaceuticals across the globe: The role of regulatory regimes, *Marketing Science*, 28, 690-708.