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Cyclic patterns in the supply of coffee

Background

In the context of its programme of activities, the Organization pays particular attention to problems related to production patterns which influence price movements. This report aims to analyse cyclic movements in the behaviour of production.

Action

The Council is requested to take note of this document.

CYCLIC PATTERNS IN THE SUPPLY OF COFFEE

INTRODUCTION

1. This document is an update of a previous study on research into cyclic behaviour in coffee production (document EB-3845/03) and aims to extend the observation period in order to highlight cyclic patterns in coffee production. In the methodology used for this purpose the first section involves a graphic analysis of production changes for each of the countries selected. The second section is devoted to the results of the statistical tests carried out.

2. The selection of countries is based on production and export performance over the last twenty crop years (1988/89-2008/09). Countries that recorded average production and export figures above 1 million bags during this period were selected for the study. On the basis of these criteria the following countries were selected: Africa: Cameroon, Côte d'Ivoire, Ethiopia, Kenya and Uganda; Asia and Oceania: India, Indonesia and Vietnam; Central America and Mexico: Costa Rica, El Salvador, Guatemala, Honduras and Mexico; South America: Brazil, Colombia, Ecuador and Peru. Tables 1 and 2 below show average production and exports for these countries as well as their share in world production and exports. The 17 countries selected account for 89% and 91% of average world production and exports respectively over the last twenty crop years (1988/89-2008/09).

Table 1: Average production of selected exporting countries

								Shares in world total						
	1965/66	1988/89						1965/66	1988/89					
Continent/country	2008/09	2008/09	1965-69	1970-79	1980-89	1990-99	2000-08	2008/09	2008/09	1965-69	1970-79	1980-89	1990-99	2000-08
Africa	12 101	11 658	10 368	12 577	13 687	11 505	11 434	13.3%	10.9%	15.4%	17.4%	15.2%	11.4%	9.8%
Cameroon	1 273	1 028	1 198	1 462	1 771	1 022	829	1.4%	1.0%	1.8%	2.0%	2.0%	1.0%	0.7%
Côte d'Ivoire	3 639	3 286	2 968	4 155	4 338	3 448	2 876	4.0%	3.1%	4.4%	5.8%	4.8%	3.4%	2.5%
Ethiopia	3 134	3 388	2 353	2 982	3 128	2 846	4 062	3.4%	3.2%	3.5%	4.1%	3.5%	2.8%	3.5%
Kenya	1 255	1 133	851	1 286	1 726	1 377	784	1.4%	1.1%	1.3%	1.8%	1.9%	1.4%	0.7%
Uganda	2 801	2 822	2 999	2 692	2 724	2 811	2 883	3.1%	2.6%	4.4%	3.7%	3.0%	2.8%	2.5%
Asia & Oceania	12 619	19 936	3 785	5 080	8 737	15 042	27 526	13.8%	18.7%	5.6%	7.0%	9.7%	15.0%	23.5%
India	2 814	3 921	1 094	1 729	2 353	3 541	4 678	3.1%	3.7%	1.6%	2.4%	2.6%	3.5%	4.0%
Indonesia	5 510	7 133	2 691	3 351	5 933	6 788	7 585	6.0%	6.7%	4.0%	4.6%	6.6%	6.8%	6.5%
Vietnam	4 295	8 883	0	0	451	4 712	15 263	4.7%	8.3%	0.0%	0.0%	0.5%	4.7%	13.1%
Mexico & Central America	13 317	15 353	8 721	11 170	13 814	16 023	14 696	2.1%	2.1%	1.8%	2.0%	2.4%	2.5%	1.6%
Costa Rica	1 912	2 195	1 247	1 448	2 201	2 509	1 814	2.1%	2.1%	1.8%	2.0%	2.4%	2.5%	1.6%
El Salvador	2 314	2 020	2 091	2 795	2 529	2 428	1 537	2.5%	1.9%	3.1%	3.9%	2.8%	2.4%	1.3%
Guatemala	3 135	3 959	1 900	2 355	2 823	4 117	3 945	3.4%	3.7%	2.8%	3.3%	3.1%	4.1%	3.4%
Honduras	1 716	2 506	570	878	1 471	2 148	3 078	1.9%	2.3%	0.8%	1.2%	1.6%	2.1%	2.6%
Mexico	4 239	4 675	2 912	3 694	4 790	4 822	4 322	4.6%	4.4%	4.3%	5.1%	5.3%	4.8%	3.7%
South America	41 665	48 487	33 948	31 427	40 944	46 321	52 954	45.6%	45.4%	50.3%	43.6%	45.4%	46.1%	45.3%
Brazil	27 569	32 740	24 029	19 707	25 576	30 329	37 418	30.2%	30.7%	35.6%	27.3%	28.4%	30.2%	32.0%
Colombia	11 035	12 084	7 998	9 260	12 278	12 699	11 464	12.1%	11.3%	11.9%	12.8%	13.6%	12.6%	9.8%
Ecuador	1 431	1 401	1 007	1 426	1 865	1 673	921	1.6%	1.3%	1.5%	2.0%	2.1%	1.7%	0.8%
Peru	1 630	2 263	915	1 034	1 225	1 620	3 151	1.8%	2.1%	1.4%	1.4%	1.4%	1.6%	2.7%
Total of selected countries	79 701	95 435	56 823	60 254	77 182	88 890	106 609	87.3%	89.4%	84.2%	83.6%	85.6%	88.4%	91.2%
World Total	91 306	106 723	67 457	72 083	90 164	100 544	116 917	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

In thousand bags

Table 2: Average exports of selected exporting countries

Continent/country	1965/66	1988/89	1965-69	1970-79	1980-89	1990-99	2000-08	Share in world total						
	2008/09	2008/09						1965/66	1988/89	1965-69	1970-79	1980-89	1990-99	2000-08
Africa	10 280	10 183	8 836	10 799	10 717	10 560	9 710	14.6%	12.3%	17.5%	18.9%	16.0%	13.7%	10.6%
Cameroon	1 215	1 031	1 094	1 379	1 550	1 150	801	1.7%	1.2%	2.2%	2.4%	2.3%	1.5%	0.9%
Côte d'Ivoire	3 549	3 295	2 995	4 045	3 784	3 584	3 007	5.1%	4.0%	5.9%	7.1%	5.6%	4.6%	3.3%
Ethiopia	1 571	1 818	1 270	1 386	1 381	1 412	2 329	2.2%	2.2%	2.5%	2.4%	2.1%	1.8%	2.6%
Kenya	1 211	1 185	771	1 189	1 581	1 417	837	1.7%	1.4%	1.5%	2.1%	2.4%	1.8%	0.9%
Uganda	2 735	2 854	2 707	2 799	2 421	2 997	2 736	3.9%	3.5%	5.4%	4.9%	3.6%	3.9%	3.0%
Asia & Oceania	9 662	16 077	2 148	2 979	6 317	11 703	22 709	15.7%	21.4%	5.1%	6.3%	11.0%	17.0%	26.7%
India	1 891	2 902	504	852	1 475	2 546	3 552	2.7%	3.5%	1.0%	1.5%	2.2%	3.3%	3.9%
Indonesia	4 024	5 382	1 645	2 126	4 571	5 480	5 228	5.7%	6.5%	3.3%	3.7%	6.8%	7.1%	5.7%
Vietnam	3 746	7 793	0	0	271	3 677	13 929	5.3%	9.4%	0.0%	0.0%	0.4%	4.8%	15.3%
Mexico & Central America	10 794	13 011	6 272	8 633	10 739	13 683	12 557	15.4%	15.7%	12.4%	15.1%	16.0%	17.7%	13.8%
Costa Rica	1 659	1 962	1 003	1 292	1 818	2 240	1 610	2.4%	2.4%	2.0%	2.3%	2.7%	2.9%	1.8%
El Salvador	2 133	1 877	1 838	2 516	2 377	2 229	1 495	3.0%	2.3%	3.6%	4.4%	3.5%	2.9%	1.6%
Guatemala	2 784	3 618	1 563	2 053	2 373	3 657	3 763	4.0%	4.4%	3.1%	3.6%	3.5%	4.7%	4.1%
Honduras	1 461	2 199	397	676	1 206	1 846	2 783	2.1%	2.7%	0.8%	1.2%	1.8%	2.4%	3.1%
Mexico	2 755	3 354	1 472	2 096	2 964	3 712	2 906	3.9%	4.1%	2.9%	3.7%	4.4%	4.8%	3.2%
South America	30 869	35 779	24 811	24 881	29 544	32 973	40 021	44.0%	43.3%	49.1%	43.5%	44.1%	42.6%	43.9%
Brazil	18 677	21 324	17 301	15 390	16 895	17 983	25 843	26.6%	25.8%	34.2%	26.9%	25.2%	23.3%	28.3%
Colombia	9 608	11 222	6 076	7 563	10 169	12 102	10 448	13.7%	13.6%	12.0%	13.2%	15.2%	15.7%	11.5%
Ecuador	1 177	1 180	775	1 129	1 502	1 439	801	1.7%	1.4%	1.5%	2.0%	2.2%	1.9%	0.9%
Peru	1 407	2 053	659	799	977	1 448	2 929	2.0%	2.5%	1.3%	1.4%	1.5%	1.9%	3.2%
Total of selected countries	61 604	75 050	42 067	47 291	57 317	68 919	84 997	87.8%	90.8%	83.2%	82.8%	85.5%	89.1%	93.2%
World total	70 204	82 669	50 580	57 144	67 053	77 318	91 213	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

In thousand bags

I. Graphic analysis of changes in coffee production

World production

3. There has been a steady growth in production since crop year 1965/66 with an average annual rate of 2%. Average production for crop years 2000/01 to 2008/09 was 116.9 million bags compared to 100.5 million between 1990/91 and 1999/00. However, increases in production were interrupted by falls. An increase in one crop year generally alternates with a fall in the next despite a number of exceptional situations when there were successive increases over two to five crop years (1971/72 and 1972/73, 1977/78 to 1981/82, 1998/99 and 1999/00). Falls were recorded over two consecutive crop years in 1975/76 and 1976/77, 1992/93 and 1993/94. Apart from these cases, there were alternating ups and downs from one crop year to the next following an average two-year cycle. This cyclic variation has been considerably more marked since crop year 2001/02. Table 3 shows changes in world production.

Table 3: Changes in world production since crop year 1965/66

Crop year	Change from previous year	Crop year	Change from previous year
1966/67	-26.6%	1988/89	-17.1%
1967/68	18.5%	1989/90	5.4%
1968/69	-13.0%	1990/91	-1.1%
1969/70	7.0%	1991/92	8.7%
1970/71	-11.1%	1992/93	-2.5%
1971/72	31.4%	1993/94	-8.4%
1972/73	4.2%	1994/95	2.8%
1973/74	-18.6%	1995/96	-6.9%
1974/75	24.0%	1996/97	19.0%
1975/76	-10.5%	1997/98	-3.5%
1976/77	-17.6%	1998/99	9.3%
1977/78	16.7%	1999/00	20.7%
1978/79	15.5%	2000/01	-13.7%
1979/80	0.5%	2001/02	-4.8%
1980/81	0.4%	2002/03	13.7%
1981/82	24.5%	2003/04	-14.5%
1982/83	-15.7%	2004/05	10.8%
1983/84	5.4%	2005/06	-4.0%
1984/85	-5.9%	2006/07	15.9%
1985/86	7.4%	2007/08	-7.9%
1986/87	-10.1%	2008/09	7.7%
1987/88	33.0%		

Production in Africa

4. African production has fallen steadily over the last twenty crop years. The annual average was 14.7 million bags during the period from 2000/01 to 2008/09 compared to 15.9 million bags in 1990/91 to 1999/2000. The production pattern seems to follow a one-year alternating cycle between increases and falls. Nevertheless, there are cases in which production has increased consecutively during two or more years. Over the period covered by the study, falls over two consecutive crop years occurred only twice (1977/78 and 1978/79; 2000/01 and 2001/02). On the other hand, increases over four successive crop years occurred between 1993/94 and 1996/97. Since crop year 2001/02, production has alternated between increases and falls. There is evidence of a downward trend in the total production of this region.

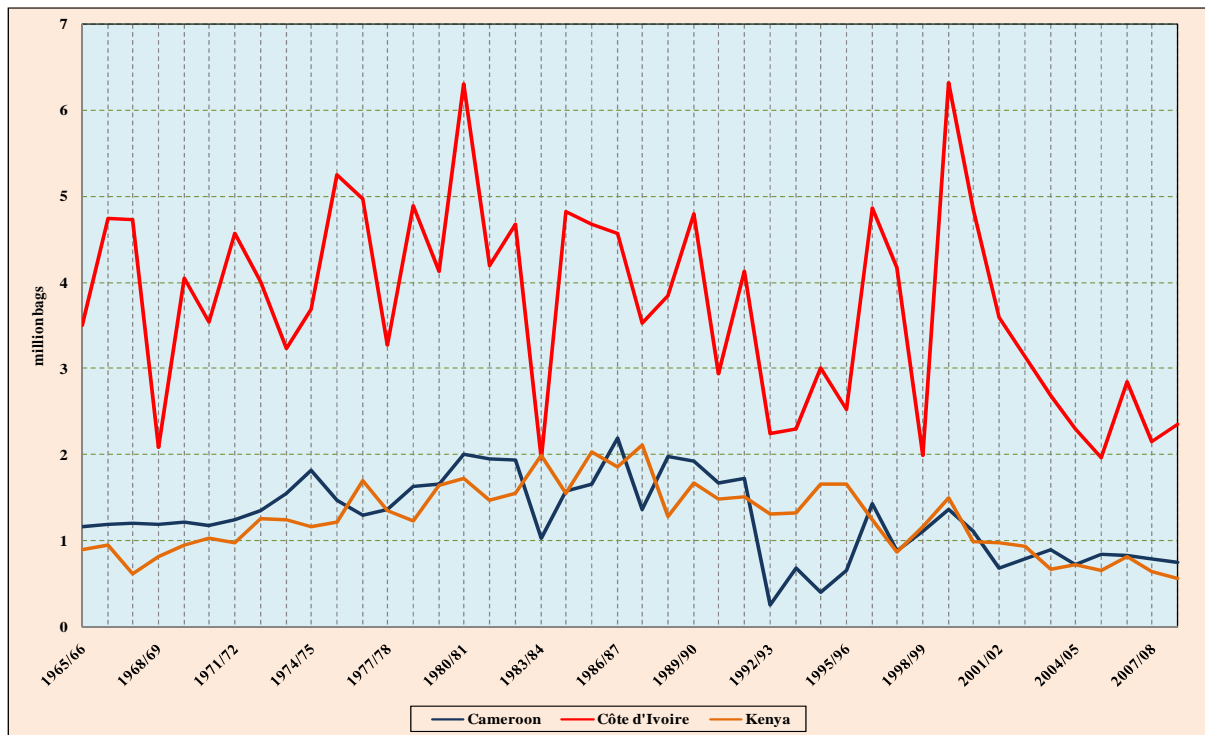
5. In the case of individual countries, it was noted that **Cameroon** recorded four consecutive years of increased production after crop year 1971/72 followed by two years of falling production before renewed increases over four consecutive crop years from 1977/78 to 1980/81. Furthermore, production has fallen in every crop year since 2006/07 (Graph 1). On the whole, then, there is no cyclic pattern in the behaviour of production in Cameroon.

6. In the case of **Côte d'Ivoire**, a biennial cycle was observed from 1965/66 to 1972/73, which was interrupted for four crop years before being resumed between 1977/78 and

1985/86. After this period, there have been sporadic alternations between increases and falls over three to five years without evidencing a precise cycle, particularly in the period from 2000/01 to 2005/06, which represents six consecutive crop years of declining production. There appears to be a return to the biennial cycle since crop year 2005/06 (Graph 1).

7. Production in **Kenya** followed a biennial cycle from 1981/82 to 1993/94 with an interruption in 1983/84. Following a period of declining production over four consecutive crop years (2000/01 to 2003/04), biennial alternation between increases and falls seems to have returned in recent crop years (Graph 1).

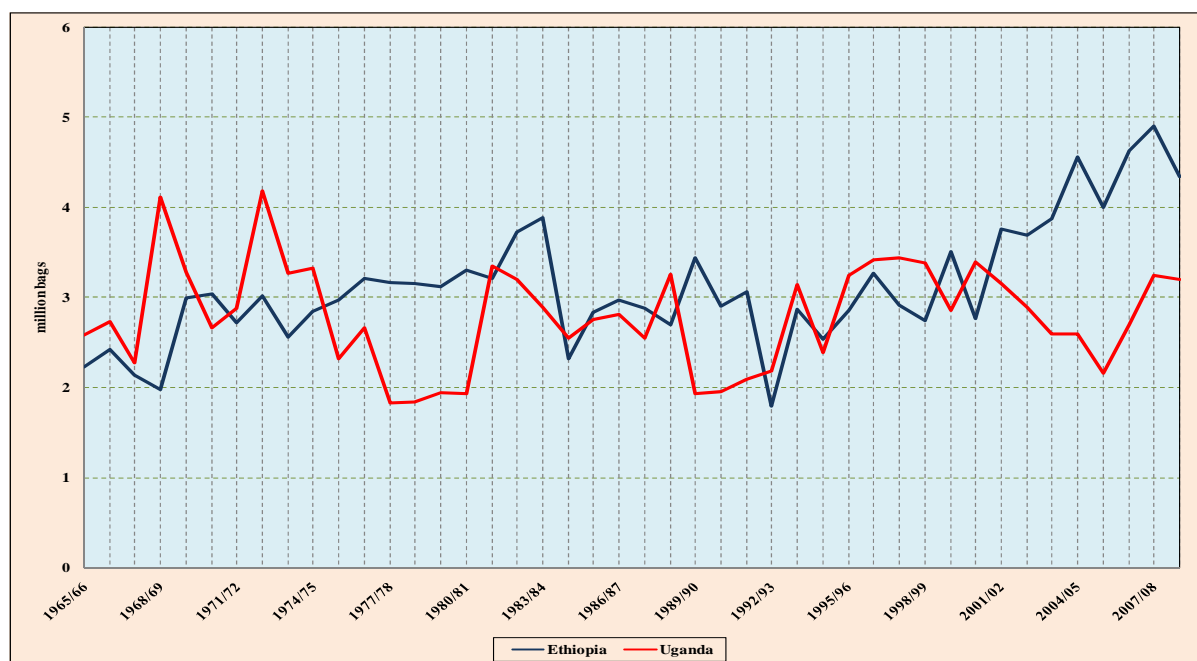
Graph 1: Production levels in Cameroon, Côte d'Ivoire and Kenya
Crop years 1965/66 to 2008/09



8. In **Ethiopia**, a biennial cycle was observed between 1988/89 and 2003/04 with a brief interruption in 1996/97 and 1998/99. However, recent observations seem to indicate a return to this cycle (Graph 2).

9. In **Uganda**, despite some interruptions, there was alternation between increases and falls in accordance with a biennial cycle from 1965/66 to 2001/02. This cycle then disappeared, with a lengthy period of falling production over five crop years from 2001/02 to 2005/06 (Graph 2).

Graph 2: Production levels in Ethiopia and Uganda
Crop years 1965/66 to 2008/09

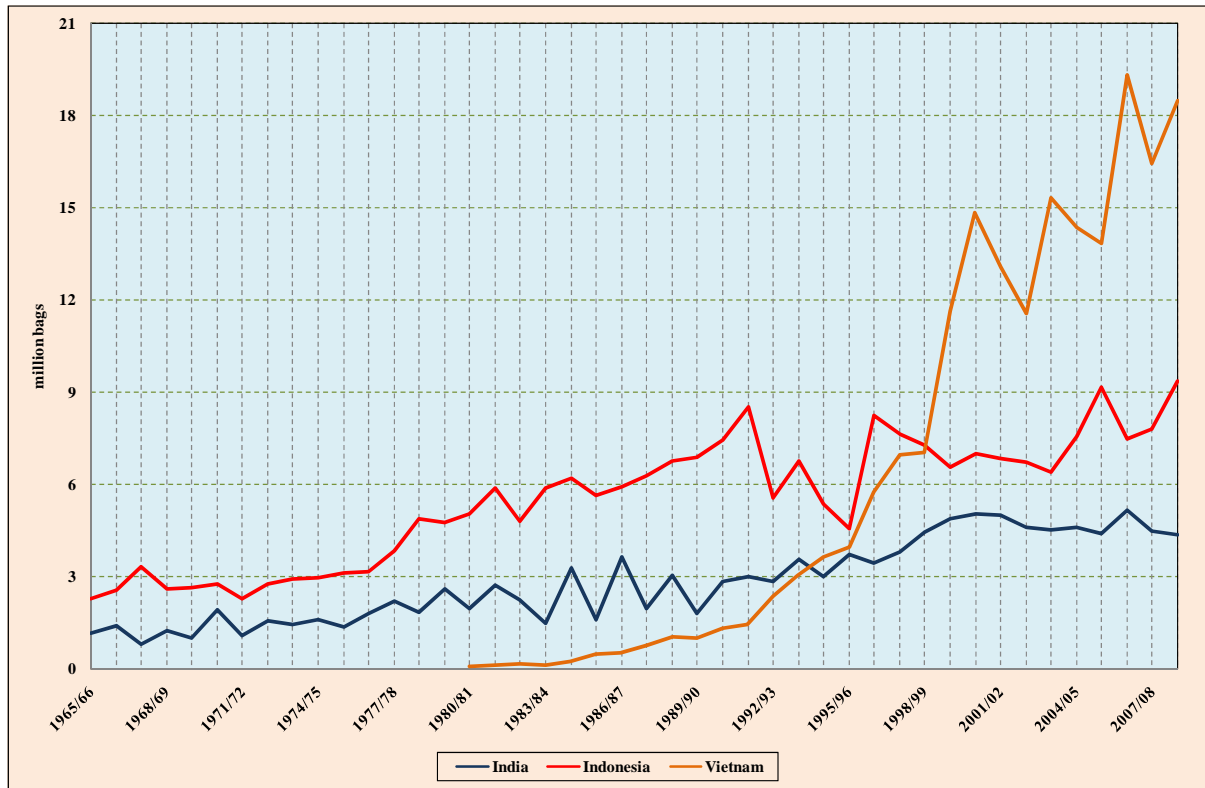


Production in Asia and Oceania

10. **Asia** and **Oceania** experienced the strongest growth in production during the period under study, particularly over the last twenty years with the emergence of the coffee industry in Vietnam. Between 1988/89 and 2008/09 production in the region averaged 23 million bags per crop year, representing an average share of 22% of world production during this period. The behaviour of total production reflected a biennial cycle from 1965/66 to 1976/77. After this period, the cycle was disrupted with production increases over three to five successive crop years whereas falls were rare and of short duration.

11. Despite some interruptions, production in **India** followed a biennial cycle over the period as a whole. Acyclic increases were recorded in crop years 1977/78, 1991/92 and from 1998/99 to 2000/01 while acyclic falls were recorded in 1983/84 and from 2002/03 to 2003/04. In the case of **Indonesia**, there was no cyclic pattern over the period from 1965/66 to 2008/09. There were, however, two periods of continual increases from 1972/73 to 1978/79 and from 1986/87 to 1991/92. Production in **Vietnam** has increased considerably since the 1980s. There were two lengthy periods of uninterrupted successive increases from 1984/85 to 1988/89 and from 1990/91 to 2000/01. There has been alternation between increases and falls since 2001/02 with an interruption in 2005/06. Graph 3 shows the production levels achieved in these countries since 1965/66.

Graph 3: Production levels in India, Indonesia and Vietnam
Crop years 1965/66 to 2008/09

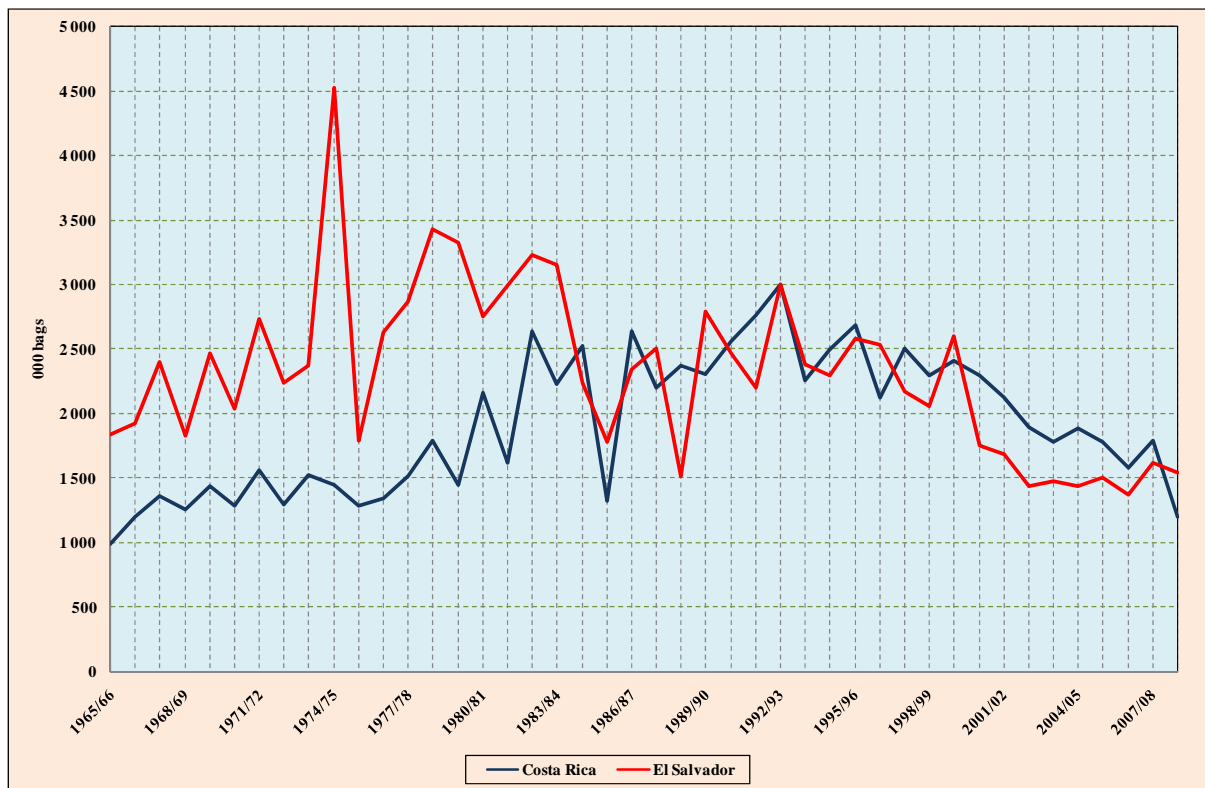


Production in Central America and Mexico

12. This region produced an annual average of 17.9 million bags over the twenty crop years from 1988/89 to 2008/09. A biennial cycle of increases and falls was observed between 1965/66 and 1973/74. Since crop year 1974/75 this cycle ceased to be regular, with increases and falls sometimes persisting over more than two consecutive crop years. The longest period of falling production was recorded from 2000/01 to 2004/05 followed by three consecutive crop years of increases (2005/06 to 2007/08). On this evidence, production for the region as a whole does not appear to follow a cyclic pattern.

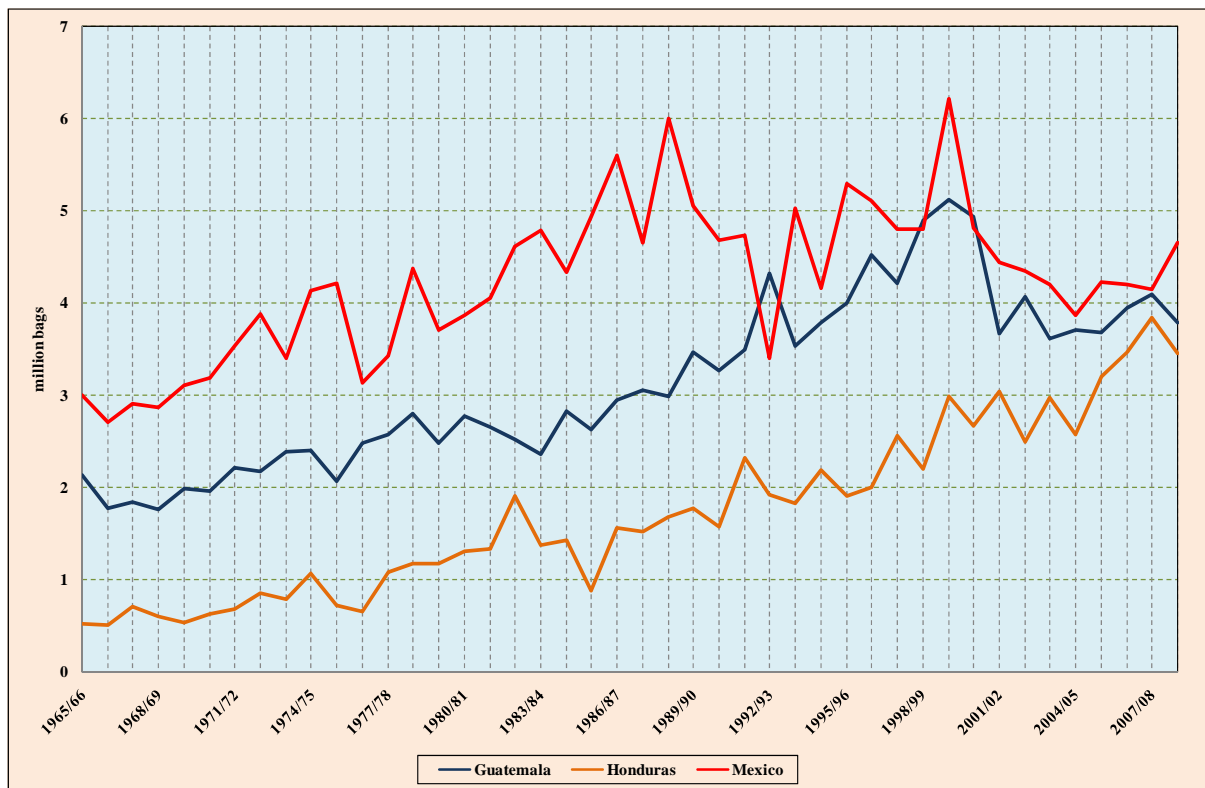
13. Production in **Costa Rica** over the period from 1965/66 to 2008/09 seems to have followed a biennial cycle despite some interruptions; particularly during the lengthy period of falling production between 2000/01 and 2003/04 (Graph 4). In the case of production in **El Salvador**, the biennial cycle was regularly interrupted after crop year 1974/75. There are signs, however, of a return to the biennial cycle since crop year 2002/03 (Graph 4).

Graph 4: Production levels in Costa Rica and El Salvador
Crop years 1965/66 to 2008/09



14. In **Guatemala**, production in the period from 1965/66 to 1973/74 was marked by regular alternations between increases and falls, indicating the presence of a biennial cycle. Between 1975/76 and 2000/01 this pattern was no longer maintained, however, with recorded interruptions often lasting more than two years. Since crop year 2001/02 the biennial cycle seems to have been resumed notwithstanding an interruption over two successive crop years in 2006/07 and 2007/08. In **Honduras** production seems to follow a biennial cyclic pattern. Since crop year 1997/98, the cycle was interrupted only once when production increased over two crop years in 2006/07 and 2007/08. Production in **Mexico** followed a biennial cycle from 1965/66 to 2000/01 with some interruptions. After a lengthy period of low prices between 2000/01 and 2004/05, however, the cycle seems to have disappeared. Graph 5 shows the production levels in the latter three countries in this region.

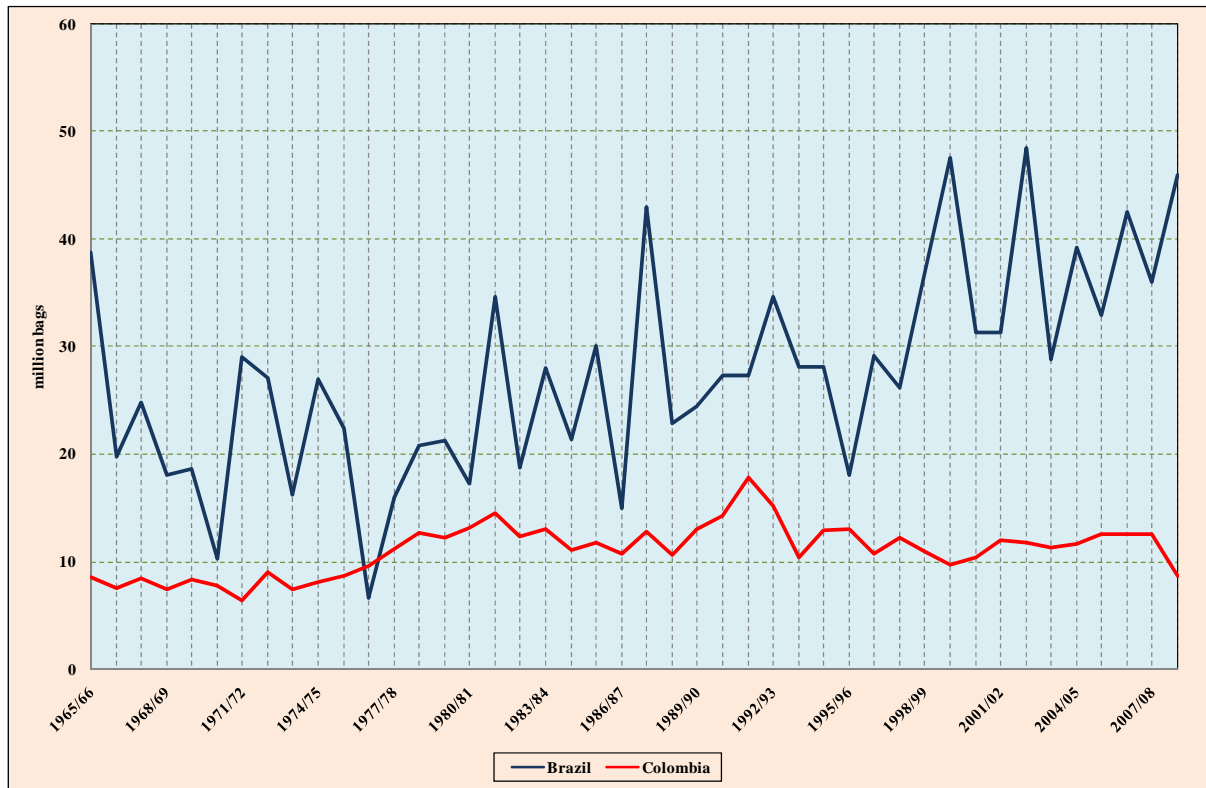
Graph 5: Production levels in Guatemala, Honduras and Mexico
Crop years 1965/66 to 2008/09



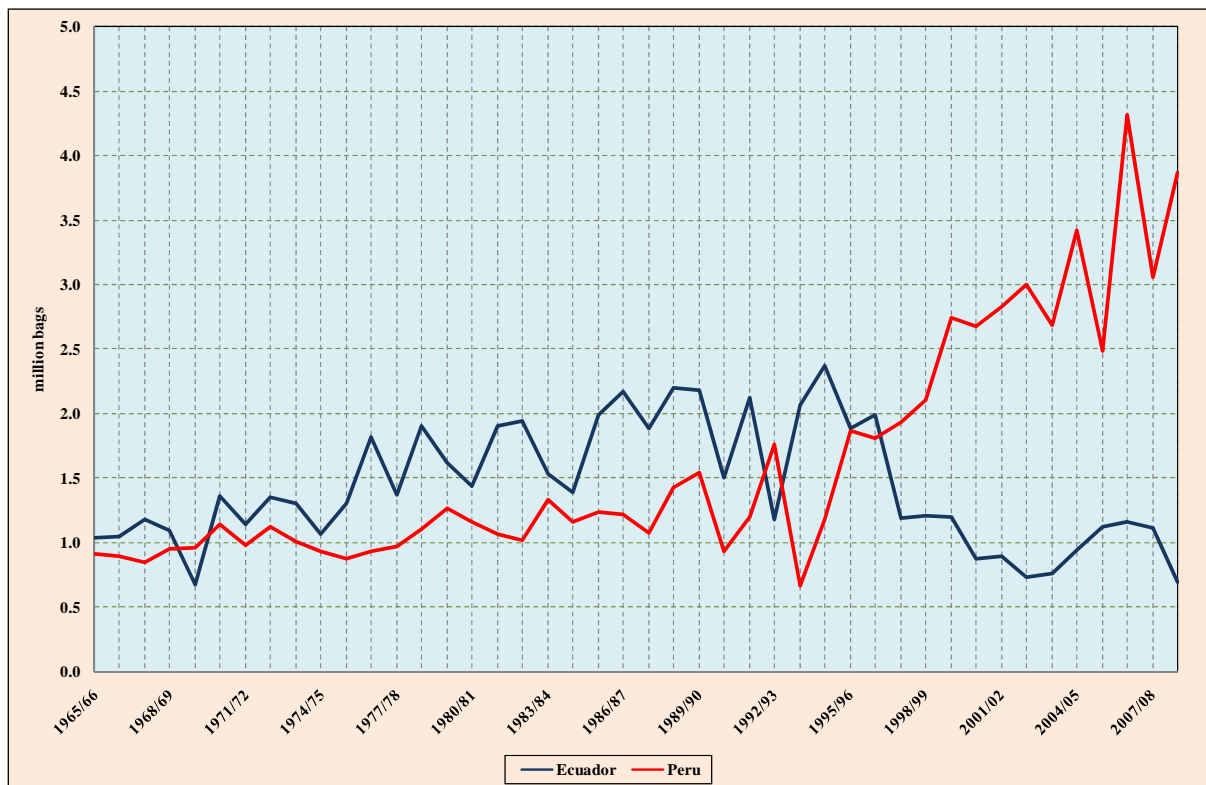
Production in South America

15. Production in this region averaged 50 million bags, representing 47% of average world production. Production behaviour followed a biennial cycle with six interruptions during the entire period from 1965/66 to 2008/09. Production in **Brazil** follows the same cyclic pattern characterized by alternations between increases and falls, with the exception of six interruptions during the period studied (Graph 6). Production in **Colombia** followed a biennial cycle between 1965/66 and 1989/90 with only three interruptions: in 1971/72, from 1974/75 to 1978/79 and in 1981/82. However, no biennial cycle was observed during the rest of the period (Graph 6). Alternation between production increases and falls in **Ecuador** does not follow a given cyclic pattern and even the biennial cycle appeared only sporadically during the period studied. A biennial production cycle was not observed in **Peru** until crop year 2002/03. Graph 7 shows the production levels achieved in these two countries.

Graph 6: Production levels in Brazil and Colombia
Crop years 1965/66 to 2008/09



Graph 7: Production levels in Ecuador and Peru
Crop years 1965/66 to 2008/09



II. Evidence of cyclic patterns based on statistical methods

A. Methodology

16. Overall graphic analysis of production movements indicated the presence of cyclic patterns in the behaviour of coffee production in a number of countries. Although this analysis provides an overall view of the phenomenon observed over a relatively significant period (44 coffee years) and highlights some aspects of the evolution of production, it does not provide sufficient evidence of cyclic movements in coffee production. For this reason, time series analysis was used to carry out tests for seasonality.

17. Various techniques can be used to assess seasonal variations in a time series. The first category of models considers the data as a function of time [$Y=f(t)$]. The ordinary least square (OLS) method is used for tests together with other iterative methods. The second category of models seeks to determine each value in the time series as a function of the values that precede it. The general form of the equation in this category is $Y=f(Y_{t-1}, Y_{t-2}, \dots)$. Models such as ARIMA (Auto-Regressive Integrated Moving Average) were used in tests. The Box-Jenkins model developed in 1976 is an example of this type.

18. Linear regression techniques were used to model the seasonal component of the time series. Insofar as a series shows trend and seasonality the general form of decomposition is determined using the following equation:

$$Y_t = X_t + S_t + U_t$$

Y_t = Production for the year t

X_t = Production trend component

S_t = Seasonal or cyclic production component

U_t = Random component – Purely random disturbances (Risks, wars, floods, frosts, other disasters)

t = Time; $t = 1, 2, 3, \dots, N$ (number of years of production)

19. When observations are not correlated, simple linear regression provides a reliable trend estimate. In the case of time series on coffee production, since observations are correlated, it is advisable to use a different model. Observations of production in all the countries selected are, in fact, correlated since all the tests showed that the series are autoregressive of the first order (AR_1). The autoregressive process is a regression model for time series in which the series is explained by its past values rather than by other variables.

20. ARCH (Auto-Regressive Conditional Heteroscedasticity) and GARCH (Generalized Autoregressive Conditional Heteroscedasticity) tests were also carried out to determine whether random variables such as natural disasters (frosts, drought) aggravated volatility in such a way that cyclic behaviour could not be perceived, particularly in the case of Brazil.

B. Results and observations

Table 4: Econometric test results¹

	Cycles	Amplitude of cycle in relation to trend	Coefficient of determination R ²
World production	2-year cycles	5.56%	0.65
Africa			
Cameroon	No cycle	0%	0.60
Côte d'Ivoire	No cycle	0%	0.80
Ethiopia	5-year cycle	0.45%	0.52
Kenya	No cycle	0%	0.29
Uganda	No cycle	0%	0.30
Asia & Oceania			
India	2-year cycle	0.30%	0.70
Indonesia	No cycle	0%	0.31
Vietnam	No cycle	0%	0.25
Central America & Mexico			
Costa Rica	No cycle	0%	0.46
El Salvador	2-year cycle	0.02%	0.37
Guatemala	No cycle	0%	0.44
Honduras	2-year cycle	0.13%	0.54
Mexico	2-year cycle	0.006%	0.30
South America			
Brazil	2-year cycle	12%	0.72
Colombia	No cycle	0%	0.20
Ecuador	No cycle	0%	0.35
Peru	No cycle	0%	0.25

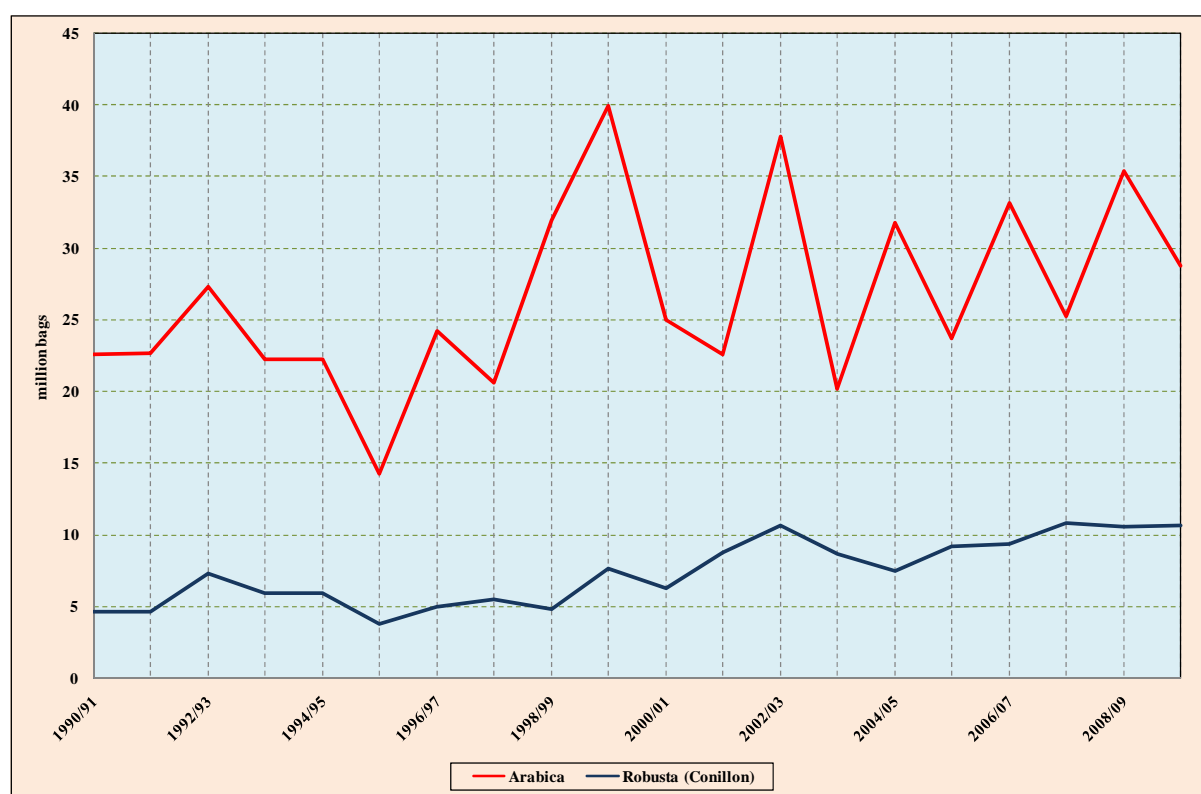
21. The test results show that there is no statistically significant cycle in the behaviour of production in most exporting countries. The only countries showing evidence of cycles were Brazil, El Salvador, Honduras, India and Mexico. With the exception of Brazil, however, the statistical coefficients are so weak that the cycles identified are not significant.

22. In the case of Brazil, production follows a random biennial cycle. The amplitude of this cycle is equivalent to 12% of the trend. However, when random variables (dummy variables) are introduced to isolate periods of frost and drought (1976, 1981, 1985, 1994), the biennial cycle disappears. It is possible that these events provoked the existence of a cycle. After breaking down the behaviour of Arabica and Robusta production, we can establish the existence of a cycle in the case of Arabicas but not in the case of Robustas. Prior to 1988 the main production of Brazil was Arabica. The breakdown between Arabica and Robusta from 1990/91 onwards shows strong evidence that the cyclic nature of Arabica production is responsible for the variation in the country's total production. In fact, in accordance with the

¹ The econometric test results are similar to those obtained in the initial version of the study (document EB-3845/03).

biennial production cycle of Arabicas in Brazil, an abundant crop in one crop year is followed by a much smaller crop in the next. Arabica trees that have borne large quantities of cherries need time to recover during the next crop year and are characterized by poor flowering. This variation is sometimes accentuated by the impact of climatic factors associated with droughts or frosts. Since Brazilian production accounts for over 30% of world production, the impact of the biennial cycle that characterizes it is also reflected at world level.

Graph 8: Production levels in Brazil by type of coffee
Crop years 1990/91 to 2008/09



Conclusions

23. Graphic analysis and econometric tests indicate that, with the exception of Brazil, there is no consistent long-term cycle in the coffee production of almost all the countries studied. In the case of countries where cycles were detected, the statistical parameters are not sufficiently significant to confirm their existence. Some cyclic patterns of production can be observed in some short-term intervals during the overall period under analysis, such as in the case of Peru from crop years 2002/03 to 2008/09, however these are not statistically significant.

24. The lack of statistical significance of cyclic patterns in countries other than Brazil, despite their apparent presence in certain periods under graphic analysis, may be attributable to one or a combination of the following factors:

- the prevalence of sun-grown (unshaded) planting in Brazil results in increased productivity (fructification). The cherries consume the reserves of carbohydrates and metabolites present in the plant and leave fewer nutrients for its branches and roots, thereby reducing potential production in the following crop;
- favourable climatic conditions in one year tend to result in increased productivity, thus strengthening the biennial cycle and synchronizing it across producing regions. In addition, extreme climatic events (frosts and droughts) also tend to make the stress on trees more uniform and accentuate the existing biennial cycle;
- strip-picking techniques used in Brazil mean that coffee trees carry a full load of cherries for a longer time than occurs with selective picking that prevails in most other Arabica producing countries. This practice intensifies the biennial cycle since trees in Brazil come under greater stress to provide nutrients to the cherries; and
- the biennial cycle may be exacerbated at high southern latitudes, such as those where the majority of Brazil's coffee plantations are located, because precipitation is more concentrated and seasons are more well-defined than in producing regions nearer the Equator.

Further research, including comparisons among producing regions in Brazil, is required to reach more definitive conclusions as to the relative influence of each of these causes.

25. It should be noted that test results are not solely dependent on the reliability of the available statistics, but also on the model and econometric software programme used. A complete model integrating prices and production costs would permit a better understanding of cyclic production behaviour.