

**CENTRAL BANK OF THE REPUBLIC OF TURKEY**

**THE REAL EXCHANGE RATE DEFINITIONS AND  
CALCULATIONS**

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**Publication No: 97/1**

**ANKARA  
January 1997**

## **1. Introduction**

Basically, the real exchange rate can be defined as the nominal exchange rate that takes the inflation differentials among the countries into account. Its importance stems from the fact that it can be used as an indicator of competitiveness in the foreign trade of a country. The importance of the real exchange rate for a Central Bank is related with the effects of the real exchange rates on the Central Bank balance sheet and, in turn, with its ability to conduct a prudent monetary policy. Any changes in the real exchange rates would lead to fluctuations in short term capital flows. These fluctuations would then have an affect on the Central Bank's net foreign assets. The changes in the volume of net foreign assets would lead to changes in the volume of currency in circulation on the liability side of the balance sheet. Thus, the changes in the volume currency in circulation would necessitate the management of the liquidity fluctuations in the economy through the utilization of the monetary policy tools by the Central Bank, whose final objective is price stability.

Because of the important role it plays in an economy as mentioned above, the real exchange rate has been one of the most debated issues both in theory and the practice. This study aims at summarizing the existing definitions, calculation methods and interpretations of the real exchange rates. Within this context, the first part of the study will introduce different definitions of the real exchange rates. The calculation methods will be discussed in the second part. Finally, several points that should be taken into account in the interpretation of the real exchange rate movements will be highlighted.

## **2. The Real Exchange Rate Definitions**

The various definitions of the real exchange rate can mainly be categorized under two main groups. The first group of definitions is made in line with the purchasing power parity. The second group of definitions, on the other hand, is based on the distinction between the tradable and the non-tradable goods. Although they can coincide in some very special cases, these definitions usually give different results.

## 2.1. Purchasing Power Parity

According to this definition, the real exchange rate can be defined in the long run as the nominal exchange rate ( $e$ ) that is adjusted by the ratio of the foreign price level ( $P^f$ ) to the domestic price level ( $P$ ). Mathematically, it can be shown as

$$r_{PPP} = e \frac{P^f}{P}$$

In terms of this definition, the decline in the  $r_{PPP}$  can be interpreted as the real appreciation of the exchange rate.

## 2.2. The Definition on the Basis of the Tradable and Non-tradable Goods

This definition takes the relative price of the tradables and non-tradables in the country as an indicator of the country's competitiveness level in the foreign trade. The rationale behind this definition is that the cost differential between the countries are closely related with the relative price structures in these economies.

Under the assumption that the prices of the tradables will be equal all around the world, the real exchange rate defined on the basis of tradable and non-tradable goods distinction can be mathematically represented as:

$$r_r = \frac{P_t}{P_n} = e \frac{P_t^*}{P_n}$$

In this definition,  $P_t$  and  $P_t^*$  stand for the domestic and international prices of the tradables respectively, while the prices of the non-tradables are denoted by  $P_n$ . In this definition, the decline of  $r_r$  indicates the real appreciation of the domestic currency.

A numerical example may be useful for showing how to use the second definition as a measure of competitiveness. In any period, for example in 1995, we can assume that the price of the tradables and non-tradables are 1 and 4 respectively. In this case, the real exchange rate for that year will be 0.25. Now let us assume that the price of the tradables remains the same while the price of the non-tradables increases to 5 in the following year,

indicating that the new real exchange rate becomes 0.20. In this example, while the amount of non-tradables to get 1 unit of tradables was equal to 4 units in 1995, in 1996 it becomes 5 units implying a higher domestic relative price of tradables. Under the assumption that the price structure in the foreign country is unchanged, higher relative price of non-tradables results in a deterioration in the country's level of competitiveness. The definition above can only be made by considering the ratio of the prices of the exportables or importables to the prices of the non-tradables.

Both definitions in the previous sections rely on the assumption that the home country has only one trading partner. However, in the real world, such an assumption is invalid. By considering this fact, we can make a third definition called the real effective exchange rate. In this definition, the real exchange rates corresponding to the trading partners of a country are used by some weighting criteria. The share of the foreign countries in a country's total foreign trade volume or the share of the currencies used in the foreign trade transactions can be given as examples of this weighting criteria.

### **3.The Problems in the Calculation of the Real Exchange Rates**

#### **3.1. The Choice of the Price Index:**

In practice, different price indices can be used in the calculation of the real exchange rates on the basis of purchasing power parity. The wholesale price index (WPI) and the consumer price index (CPI) are two of the leading indices that can be used in these calculations. The gross domestic product (GDP) deflator and producers price index (PPI) are also among the alternatives. The most important criticism to the real exchange rates calculated by using the WPI is that the commodities under this index is formed of tradables that are similar in nature. It is argued that the prices of these commodities are not be expected to differ substantially when measured in a common currency unit. Therefore, the movements in a real exchange rate index calculated by using the WPI would not represent the changes in a country's competitiveness level sufficiently. The same criticism is also valid for the PPI. Although in theory the PPI includes the prices of the services sector, in practice such an index includes the prices of the industrial and agricultural sectors, which are categorized as tradables.

On the other hand, the main problem with the real exchange rates calculated by using the CPI is that the CPI mainly includes the non-tradable commodities. The main problem with the GDP deflator is that this series is not available on the monthly basis.

The problem associated with the real exchange rates calculated on the basis of the distinction between the tradable and the non-tradable commodities is that the price indices for such commodity groups are not directly available. Thus, in practice special price indices that are capable of reflecting tradable/non-tradable distinction are constructed. In the literature it is suggested that the most practical solution to this problem is to use the CPI of the foreign countries as representing the tradable prices and to use the WPI of the home country as representing the non-tradable prices. The rationale behind this suggestion is that the WPI is mainly composed of non-tradables while the CPI mainly includes the non-tradable commodities.

### **3.2. Choosing Base Year in the Construction of Indices:**

In most cases, the real exchange rate calculations described above are converted into indices by taking a certain year as the base year. However, the characteristics of the base year become the main issue in the disputes as how to interpret the developments in the real exchange rates. In fact, the real exchange rate movements based on different years can be interpreted quite differently. The main criterion for the base year is that both the internal and the external equilibrium should be met simultaneously in that specific year.

Another factor that should be taken into account in the real exchange rate calculation is the definition of the effective real exchange rate. The problem at this point is to choose the countries that are to be included in the calculations. The most widespread method is to choose the countries according to the weights of their currencies in the foreign trade volume of a given country. For example, the International Monetary Fund determines the country weights by using the foreign trade data of the commodities in the agriculture and manufacturing sector. These weights are used in the calculation of the nominal exchange rate of a given country. Then, in order to render comparison possible between many countries, real effective exchange rates are calculated after correcting the nominal rate with the consumer price indices of each country. Base years of real effective exchange rate indices are modified in every 10 years.

#### **4.Important Points in the Analysis of the Real Exchange Rate Developments**

The first point in the analysis of exchange rate is to choose a base year such that, in that specific year, a given economy maintains both internal and external equilibrium. Therefore, it may be misleading to make comparisons with the preceding period. For example, the exchange rate in 1996 may appreciate in real terms compared to 1995. However, it may show no change in the real value when it is compared to the base year, which is 1987.

Another point in the analysis is that monetary authority does not have the absolute control over the real exchange rate movements. Certain developments like foreign capital movements, changes in the terms of trade or productivity increases due to technological innovations may cause alterations in the real value of the exchange rate. Such movements are the consequences of the functioning of the economic laws. Hence, improper means of removing these effects may adversely influence the economy as a whole.

The last point to be mentioned is that the real depreciation of the exchange rate may cause unexpected adverse effects on the foreign trade balance. This fact is named as the J-curve effect in the literature. It is the lagged influence of the exchange rate changes on the price and quantity components of imports in terms of domestic currency. The main reason behind this is that both export and import connections are confirmed in advance. Therefore, in the short run, the real depreciation of the exchange rate does not cause the expected reduction in import volume. On the other hand, the value of the existing import volume in terms of domestic currency increases with the real depreciation. Hence, an adverse influence on the foreign trade balance is observed.

However, since the quantity effect dominates the price effect in the long run, the expected influence of the real depreciation of the exchange rate on foreign trade balance is observed eventually. On the other hand, it should also be mentioned that, depending on the shares of intermediary and investment goods in total imports, the real depreciation of the exchange rate might not lead to a reduction in imports as expected by the theory.

### **Appendix\*:**

Alternative domestic and foreign prices as well as base years are used in the calculation of real effective exchange rates. A currency basket which is composed of 1 US dollar and 1.5 German mark is used as the nominal exchange rate. Wholesale prices, consumer prices and private manufacturing sector prices are used as domestic price indices. In addition, wholesale and consumer prices of US and Germany are used as foreign price indices and they are weighted according to the respective weights of the money in the nominal currency basket. Furthermore, 1987 and 1994 are taken as the base years, respectively, in order to reveal the effects of different sets of weights in the construction of the price indices.

The formula  $r = e \frac{p^*}{p}$  is used in the construction of the index series. Increases in the value of indices show the real depreciation of the Turkish lira.

Abbreviations used in the figures are given as follows:

r :Real Effective Exchange Rate Index

e :The Average Value of Currency Basket in TL terms

p : Domestic Prices

p\*: Foreign Prices

WPI: Wholesale Price Index

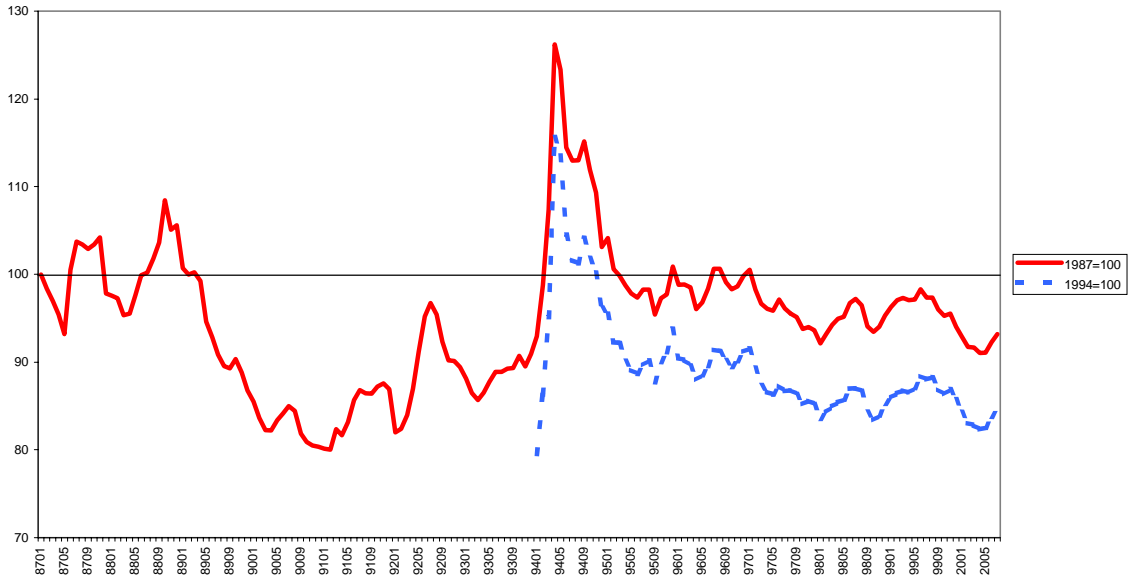
CPI: Consumer Price Index

PRIMAN: Private Sector Manufacturing Price Index

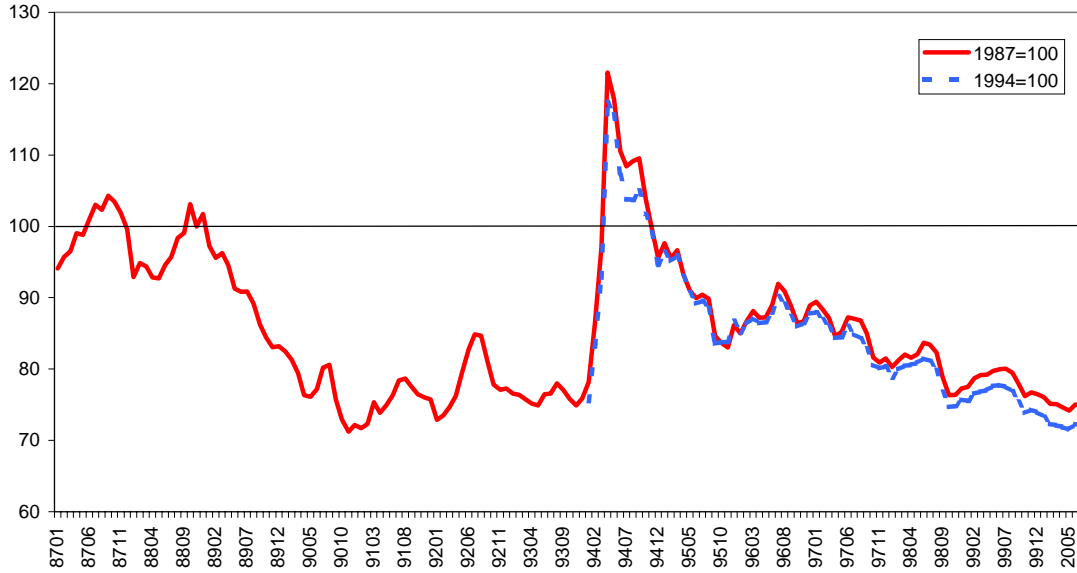
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\* The calculations of the real effective exchange rate indices are different from the Turkish version of the study. US dollar and German mark were equally weighted (0.5) in the Turkish version. Private sector manufacturing prices were not included in the calculations either.

**REAL EFFECTIVE EXCHANGE RATE**  
**P\*=WPI, P=WPI**

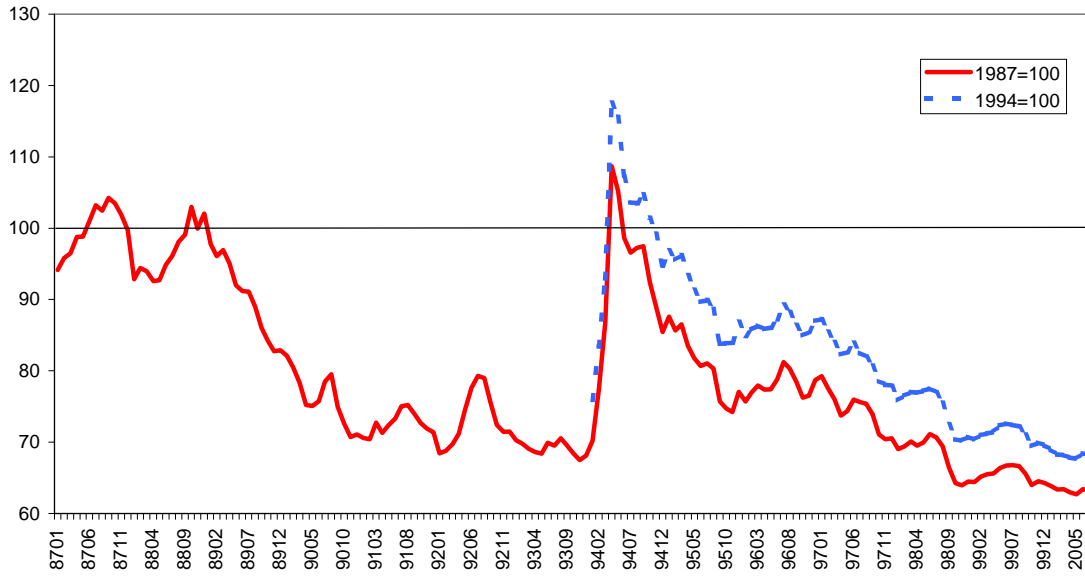


**REAL EFFECTIVE EXCHANGE RATE**  
**P\*=CPI, P=CPI**

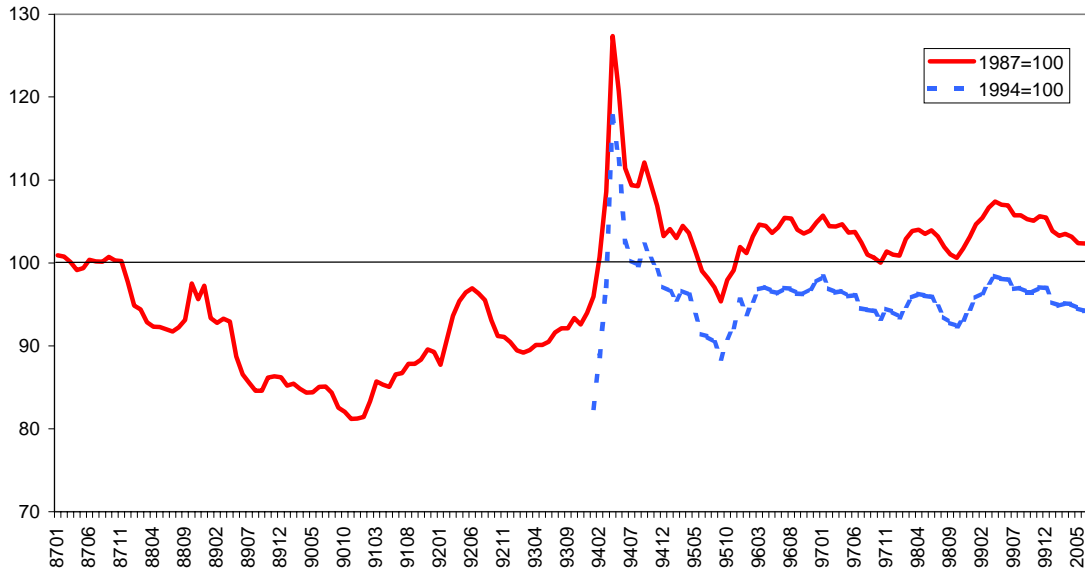




**REAL EFFECTIVE EXCHANGE RATE**  
**P\*=WPI, P=CPI**



**REAL EXCHANGE RATE**  
**P\*=WPI, P=Private Sector Manufac. Price Index**



## REAL EFFECTIVE EXCHANGE RATE (1994=100)

P*	WPI	CPI	WPI	WPI	P*	WPI	CPI	WPI	WPI
P	WPI	CPI	CPI	Pri. Man.	P	WPI	CPI	CPI	Pri. Man.
9401	79.5	75.5	75.9	82.5	9705	86.3	84.5	82.6	96.0
9402	86.3	83.3	83.4	88.8	9706	87.3	86.0	83.9	96.1
9403	95.1	92.8	93.0	97.2	9707	86.7	84.9	82.6	94.5
9404	115.6	117.4	117.6	117.7	9708	86.8	84.3	82.0	94.3
9405	113.5	115.7	115.6	112.5	9709	86.3	82.9	80.7	94.2
9406	104.5	107.3	107.2	102.5	9710	85.2	80.6	78.6	93.3
9407	101.6	103.8	103.6	100.2	9711	85.6	80.1	78.1	94.5
9408	101.3	103.7	103.5	99.7	9712	85.2	80.4	77.9	94.1
9409	104.1	105.0	104.7	102.2	9801	83.5	78.8	75.9	93.5
9410	101.9	101.7	101.5	100.5	9802	84.3	79.9	76.5	94.8
9411	100.2	99.2	99.2	99.1	9803	84.9	80.5	77.0	95.8
9412	96.2	94.6	94.7	97.1	9804	85.4	80.6	76.9	96.3
9501	95.5	96.4	96.9	96.6	9805	85.7	80.9	77.2	96.1
9502	92.3	95.1	95.5	95.6	9806	87.0	81.5	77.5	95.9
9503	92.2	95.9	96.2	96.6	9807	87.0	81.1	77.0	94.7
9504	90.1	93.1	93.4	96.2	9808	86.7	79.9	75.5	93.5
9505	89.1	90.7	91.3	93.7	9809	84.3	76.8	72.5	92.8
9506	88.7	89.2	89.6	91.4	9810	83.4	74.7	70.4	92.4
9507	89.6	89.5	89.9	91.1	9811	83.9	74.8	70.2	93.2
9508	90.2	88.5	88.7	90.4	9812	85.2	75.7	70.8	94.5
9509	87.7	83.6	83.8	88.5	9901	86.0	75.6	70.4	95.8
9510	90.0	83.8	83.9	91.0	9902	86.4	76.5	71.0	96.4
9511	91.1	83.8	83.9	92.3	9903	86.8	76.8	71.2	97.6
9512	93.8	86.7	86.9	95.5	9904	86.5	77.0	71.5	98.4
9601	90.5	85.1	84.9	93.8	9905	87.0	77.6	72.3	98.1
9602	90.3	86.4	85.8	95.5	9906	88.4	77.7	72.6	97.9
9603	89.6	87.2	86.4	96.8	9907	88.0	77.5	72.4	96.8
9604	88.0	86.4	85.8	97.1	9908	88.3	76.9	72.2	97.0
9605	88.5	86.6	86.1	96.6	9909	86.9	75.4	71.0	96.5
9606	89.5	87.9	87.2	96.3	9910	86.3	73.8	69.4	96.5
9607	91.4	90.2	89.3	97.0	9911	86.9	74.3	70.0	97.1
9608	91.2	89.2	88.2	96.9	9912	85.8	74.0	69.6	97.0
9609	90.2	87.4	86.4	96.3	2001	84.3	73.3	69.0	95.3
9610	89.5	85.9	85.0	96.3	2002	83.0	72.3	68.3	94.8
9611	90.1	86.5	85.5	96.9	2003	82.8	72.1	68.2	95.1
9612	91.2	87.8	87.0	97.7	2004	82.3	71.9	67.9	95.0
9701	91.6	87.9	87.2	98.3	2005	82.5	71.5	67.7	94.5
9702	89.4	87.0	85.5	96.9	2006	83.8	72.3	68.4	94.2
9703	87.4	86.0	84.0	96.4	2007	84.6	72.2	68.3	94.3
9704	86.6	84.4	82.3	96.6					

Increase in the index shows real depreciation of the Turkish lira against the currency basket, composed of 1 USD and 1.5 DEM.

**REAL EFFECTIVE EXCHANGE RATE**  
(1987=100)

P*	WPI	CPI	WPI	WPI	P*	WPI	CPI	WPI	WPI
P	WPI	CPI	CPI	Pri. Man.	P	WPI	CPI	CPI	Pri. Man.
8701	100.0	94.1	94.2	100.9	9311	89.5	74.9	67.5	92.6
8702	98.4	95.7	95.8	100.8	9312	90.9	75.9	68.1	93.9
8703	97.0	96.5	96.5	100.1	9401	92.9	78.2	70.2	95.9
8704	95.4	99.0	98.8	99.2	9402	98.8	86.6	77.5	100.7
8705	93.2	98.8	98.8	99.4	9403	107.4	97.1	86.8	108.6
8706	100.5	101.0	101.0	100.4	9404	126.2	121.6	108.7	127.3
8707	103.7	103.0	103.2	100.2	9405	123.3	117.9	105.2	120.7
8708	103.4	102.3	102.5	100.2	9406	114.4	110.5	98.6	111.4
8709	102.9	104.3	104.2	100.7	9407	113.0	108.4	96.6	109.4
8710	103.4	103.5	103.5	100.3	9408	113.0	109.2	97.2	109.3
8711	104.2	101.9	101.9	100.2	9409	115.2	109.5	97.5	112.1
8712	97.8	99.6	99.7	97.7	9410	111.9	103.9	92.5	109.5
8801	97.6	92.9	92.9	94.9	9411	109.3	99.6	88.9	106.9
8802	97.3	94.9	94.4	94.4	9412	103.1	95.6	85.5	103.2
8803	95.4	94.4	94.0	92.8	9501	104.1	97.6	87.6	104.1
8804	95.5	92.8	92.6	92.3	9502	100.6	95.5	85.7	103.0
8805	97.6	92.7	92.7	92.3	9503	99.9	96.7	86.5	104.5
8806	99.9	94.6	94.9	92.0	9504	98.7	93.2	83.5	103.6
8807	100.2	95.7	96.1	91.7	9505	97.8	91.0	81.8	101.4
8808	101.8	98.4	98.1	92.2	9506	97.3	89.9	80.7	99.0
8809	103.6	99.1	99.1	93.1	9507	98.3	90.4	81.0	98.2
8810	108.5	103.1	103.0	97.5	9508	98.3	89.8	80.3	97.1
8811	105.1	100.0	99.9	95.6	9509	95.4	84.6	75.7	95.4
8812	105.6	101.7	102.0	97.2	9510	97.3	83.7	74.7	97.9
8901	100.7	97.2	97.8	93.3	9511	97.7	83.0	74.2	99.1
8902	100.0	95.6	96.1	92.8	9512	100.9	86.2	77.1	101.9
8903	100.2	96.3	96.9	93.3	9601	98.8	85.0	75.7	101.2
8904	99.2	94.6	95.0	92.9	9602	98.9	86.8	76.9	103.2
8905	94.6	91.3	92.0	88.7	9603	98.5	88.2	78.0	104.6
8906	92.8	90.9	91.2	86.6	9604	96.0	87.2	77.3	104.4
8907	90.8	90.9	91.1	85.6	9605	96.8	87.2	77.4	103.6
8908	89.6	89.1	89.0	84.6	9606	98.4	89.0	78.8	104.3
8909	89.3	86.2	86.0	84.6	9607	100.6	92.0	81.2	105.4
8910	90.3	84.5	84.3	86.1	9608	100.7	90.9	80.3	105.4
8911	88.8	83.1	82.7	86.3	9609	99.1	88.8	78.4	104.0
8912	86.8	83.2	82.9	86.2	9610	98.3	86.4	76.2	103.6
9001	85.5	82.5	82.1	85.2	9611	98.6	86.7	76.5	103.9
9002	83.6	81.3	80.5	85.4	9612	99.8	88.9	78.7	104.9
9003	82.2	79.4	78.3	84.8	9701	100.5	89.4	79.2	105.7
9004	82.2	76.3	75.2	84.3	9702	98.3	88.3	77.5	104.4
9005	83.4	76.1	75.1	84.4	9703	96.7	87.1	76.0	104.4
9006	84.1	77.2	75.8	85.0	9704	96.1	84.6	73.7	104.7
9007	85.0	80.2	78.5	85.1	9705	95.9	85.2	74.4	103.6
9008	84.4	80.6	79.5	84.4	9706	97.1	87.2	76.0	103.7
9009	81.9	75.7	75.0	82.6	9707	96.1	87.1	75.6	102.5
9010	80.9	72.9	72.6	82.0	9708	95.5	86.8	75.4	101.0
9011	80.5	71.2	70.7	81.2	9709	95.1	85.0	73.9	100.7
9012	80.4	72.2	71.1	81.2	9710	93.8	81.6	71.1	100.0
9101	80.1	71.7	70.6	81.4	9711	94.0	80.9	70.4	101.4
9102	80.0	72.3	70.4	83.3	9712	93.6	81.5	70.5	101.0
9103	82.4	75.3	72.7	85.7	9801	92.1	80.3	69.0	100.9
9104	81.7	73.9	71.3	85.3	9802	93.2	81.2	69.4	102.9
9105	83.1	74.9	72.4	85.0	9803	94.2	82.0	70.1	103.8
9106	85.7	76.3	73.3	86.5	9804	95.0	81.6	69.5	104.0
9107	86.8	78.4	75.0	86.7	9805	95.2	82.1	69.9	103.5
9108	86.4	78.7	75.2	87.8	9806	96.7	83.7	71.1	103.9
9109	86.4	77.5	74.0	87.8	9807	97.2	83.4	70.7	103.2
9110	87.2	76.4	72.7	88.3	9808	96.5	82.3	69.4	101.9
9111	87.6	76.0	71.9	89.5	9809	94.1	78.8	66.4	101.0
9112	86.9	75.8	71.4	89.3	9810	93.4	76.3	64.2	100.6
9201	82.0	72.9	68.4	87.7	9811	94.1	76.4	64.0	101.7
9202	82.4	73.5	68.8	90.6	9812	95.3	77.3	64.5	103.2
9203	84.0	74.7	69.7	93.6	9901	96.3	77.5	64.4	104.6
9204	87.0	76.2	71.2	95.4	9902	97.1	78.7	65.2	105.4
9205	91.2	79.6	74.6	96.4	9903	97.3	79.2	65.5	106.7
9206	95.2	82.8	77.6	96.9	9904	97.0	79.2	65.6	107.4
9207	96.7	84.9	79.3	96.3	9905	97.1	79.8	66.4	107.0
9208	95.4	84.7	79.0	95.5	9906	98.3	80.0	66.7	106.9
9209	92.3	81.0	75.6	93.1	9907	97.4	80.1	66.8	105.7
9210	90.2	77.8	72.4	91.2	9908	97.4	79.5	66.6	105.7
9211	90.1	77.1	71.4	91.1	9909	96.0	77.9	65.5	105.3
9212	89.4	77.3	71.5	90.4	9910	95.3	76.2	64.0	105.1
9301	88.1	76.6	70.3	89.5	9911	95.5	76.7	64.5	105.6
9302	86.5	76.4	69.8	89.2	9912	94.1	76.5	64.3	105.5
9303	85.7	75.8	69.0	89.5	2001	92.9	76.0	63.9	103.8
9304	86.5	75.2	68.6	90.1	2002	91.7	75.1	63.4	103.3
9305	87.8	74.9	68.4	90.1	2003	91.7	75.1	63.4	103.5
9306	88.9	76.4	69.9	90.5	2004	91.0	74.6	63.0	103.1
9307	88.9	76.6	69.5	91.6	2005	91.1	74.2	62.7	102.4
9308	89.2	78.0	70.5	92.1	2006	92.3	75.0	63.4	102.3
9309	89.3	77.0	69.6	92.1	2007	93.2	74.9	63.3	102.4
9310	90.7	75.8	68.4	93.3					