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Means of Payment and Degree of Monetization: A Suggestion and an Application to the Case of Portugal

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ABSTRACT

Given that the characteristics of the sets of means of payment available to economic agents at a given moment supply decisive information about the degree of monetization of the economy, this paper first proposes a technique to analyse these characteristics, considering their amplitude, purchasing power and density, and then applies that technique to the evolution of the monetary system of Portugal in the course of its existence as an independent country. The Portuguese case is an interesting standard for international comparisons, because it evolved over a very long time span, and sharply different degrees of monetization may be identified within it: (i) an epoch of low or negligible monetization (12th-15th century); (ii) monetization of a significant and gradually increasing part of the economy (15th-19th century); and (iii) almost full monetization (19th century on).

Introduction - Means of payment and degree of monetization: an analytical technique

The degree of monetization at a given moment is, of course, a crucial aspect of economic life. Unfortunately, direct data on the proportion of transactions settled by payments in money is seldom available, even for small samples, and one has to resort to indirect information to measure this important variable.

The first purpose of this paper is to devise an approach to the measurement problem, exploiting indirect data – the characteristics of the set of means of payment available to economic agents –

to gauge an economy's degree of monetization. The argument is that the availability of different note and coin denominations facilitates or impedes monetary transactions of different values, and that the degree of difficulty can be informative on their frequency.

The second purpose of the paper is to suggest a technique for analysing the amplitude and the density of the available set of denominations. The technique may be described concisely by reference to a few indicators:

- a) The *amplitude* of the set of means of payment, which is an indicator of the range of the transactions that may be settled using them; it may be measured as the ratio between the worth of the most and least valuable means of payment.
- b) *Purchasing power*, which is an indicator of the value of the transactions that may be settled with the means of payment; it may be measured either at constant prices or in proportion to disposable income in each period.
- c) The *density* of the set of means of payment, which is an indicator of the ease with which it is possible to settle transactions of different amounts; it may be measured as number of denominations available and the ratios between the values of successive denominations.

A synthetic indicator of density is the inverse of the geometric average of these ratios D , defined as

$$D = 1 / (M/m)^{1/n-1} = (M/m)^{-1/n-1}$$

where M is the value of the most valuable means of payment, m that of the least valuable, and n the number of denominations.

It is easy to see that:

- (i) D falls within the range $]0, 1[$, because
for given M and m , $n = 2 \Rightarrow D = m/M$ and $n \rightarrow \infty \Rightarrow D \rightarrow 1$
for a given n , $M/m \rightarrow 1 \Rightarrow D \rightarrow 1$ and $M/m \rightarrow \infty \Rightarrow D \rightarrow 0$
- (ii) D increases with the number of denominations, because
 $\partial D / \partial n = [1 / (n - 1)^2] (M/m)^{-1/n-1} \ln(M/m) > 0$
- (iii) D decreases with the amplitude, because
 $\partial D / \partial (M/m) = [-1 / (n - 1)] (M/m)^{-n/n-1} < 0$

Finally, the paper applies this analytical technique to a historical case: the Portuguese economy from the mid-12th century to the present, generally examining the situation at intervals of a quarter of a millennium.¹ Section 1 examines the situation at mid-13th century, when the first Portuguese monetary system was introduced. Section 2 deals with the early 16th century, when Portugal was deeply involved in the exploration of the recently discovered maritime route to India. Section 3 deals with the situation at mid-18th century, when Portuguese prosperity depended above all on the Brazilian colony. Section 4 considers the second half of the 19th century, when the gold standard prevailed. Section 5 discusses the situation prior to Portugal's membership in the euro area, which can be described as the last Portuguese monetary system. Section 6 comes to the present day: Portugal as part of the European Monetary Union. Section 7 concludes.

The main source for this historical analysis is the on-line museum of the Portuguese mint.² Other references include studies on the evolution of the Portuguese monetary system,³ price evolution in Portugal,⁴ and retrospective national accounts for Portugal.⁵

1. The first Portuguese monetary system

Portugal became an independent kingdom in the mid-12th century and its kings soon began to issue their own gold and silver coins (according to Muslim standards, which still prevailed in the recently reconquered Christian kingdoms of the Iberian peninsula). How-

¹ This interval was selected on the basis of a more detailed heuristic analysis of the evolution of Portuguese monetary issues: Tomás, Valério (e-book, forthcoming).

² Address <https://www.museucasadamoeda.pt>. A monetary analysis of its Portuguese coins may be found in Tomás, Valério, 2020.

³ Namely Aragão (1874-1880), Reis (1956), Vaz (1969-1970) and Amaral (1977) of a predominantly numismatic character, and Godinho (1955), Godinho (1981-1983), especially Part I, the special issue of the journal *Estudos de Economia*, vol. XII, n. 1, 1991, on Portuguese monetary history, and Sousa (2006).

⁴ Namely Valério (2001) and Valério (2017).

⁵ Namely Valério (2008) and Valério (2010).

ever, it was only in 1253 that a Portuguese monetary unit, the *libra* (pound), divided into 20 *soldos* (shillings) and 240 *dinheiros* (pence), was instituted, according to the Carolingian standards that dominated Western Christendom at the time, and Portuguese monetary issues long remained scanty.

This situation is depicted in Table 1, which summarizes the Portuguese monetary situation around 1250.

TABLE 1
Means of payment in Portugal around 1250

Minted coins	Name	Nominal value	Value at today's prices
Gold coins	<i>morabitino</i>	1.5 <i>libras</i> = 360 <i>dinheiros</i>	64 euros
Silver coins	<i>mealha</i>	1 <i>dinheiro</i>	17 cents

Remarks

- Nominal value according to the Law of 26 December 1253.
- Value at prices in the early 21st century, computed considering that today's price level is roughly 300,000,000 times higher than that of the mid-13th century, and that 1 euro has the approximate nominal value of 4,700,000 morabitanos.

The amplitude of the range of means of payment available at this early epoch of the existence of Portugal as an independent state was extremely narrow (360:1) and density too was very low (indicator of 0.003), because there were only two denominations: one corresponded to 16 per cent of average yearly income, estimated at 9 *libras* at current prices and 400 euros at today's prices; the other corresponded to 16 per cent of average daily income, estimated at 6 *dinheiros* at current prices and 1.10 euros today. Although coins from other states in the Islamic world and Western Christendom also circulated in Portugal, as many documents and the Law of 26 December 1253 itself prove, the only reasonable inference is that the degree of monetization was very low, the most valuable coins being used essentially as a means of storage of value and only very exceptionally as a means of payment, and the least valuable serving for a few current transactions, while most transactions consisted in direct exchanges (barter).

2. The Portuguese monetary system in the Age of Discovery

The Portuguese monetary situation remained as described for the rest of the medieval period; indeed, it actually worsened in the wake of the Black Death in the mid-14th century and the internal and external conflicts of the late 14th century. For a while (from the 1380s to the 1430s), gold issues ceased completely, and the only Portuguese coins available were silver and copper. At the same time extraordinary inflation had reduced the value of the *libra* by about 2,000 times.

During the 15th century, overseas expansion and the formation of the first Portuguese colonial empire in Morocco, western Africa and the Atlantic islands (Madeira, Azores, Cape Verde and islands of the Gulf of Guinea) gradually overcame the demographic, economic, political and social crisis. In monetary terms, this meant current minting of a range of gold, silver and copper coins, and replacing the excessively small monetary unit with a new one, the *real* (plural *reais*, later known, in the 19th century, as the *réis*), at the conversion rate of 1 *real* = 35 *libras*.

The discovery of the maritime route to the Indian Ocean (Vasco da Gama's voyage in 1497-1499) opened the way to a second colonial empire, now centred in the Indian Ocean and the Far East. This produced an age of prosperity, which had its monetary counterpart in the situation reflected in Table 2.

The contrast with the situation a quarter of millennium earlier is sharp: the number of coins minted was now 16, against just 2 in the medieval period. As a consequence, the amplitude of the set of means of payment increased to 24,000:1: the largest coin now had purchasing power equal to around 60 per cent of average yearly per capita income, estimated at 8,000 *reais* at current prices and 800 euros today, while the smallest coin had purchasing power equal to 1 per cent of average daily per capita income, estimated at 22 *reais* at current prices and 2.20 euros today. Even more important, the density of the set of means of payment was also significantly greater, as the maximum ratio between the coins of successive values was now 10:1, while the density indicator came up to 0.493. In other words, it

TABLE 2
Means of payment in Portugal around 1500

Minted coins	Name	Nominal value	Value at today's prices
Gold coins	<i>português de ouro*</i>	4,000 <i>reais</i>	400 euros
	<i>cruzado</i>	400 <i>reais</i>	40 euros
	<i>quarto de cruzado</i>	100 <i>reais</i>	10 euros
Silver coins	<i>português de prata*</i>	400 <i>reais</i>	40 euros
	<i>meio português de prata*</i>	200 <i>reais</i>	20 euros
	<i>tostão</i>	100 <i>reais</i>	10 euros
	<i>quatro vinténs</i>	80 <i>reais</i>	8 euros
	<i>meio tostão</i>	50 <i>reais</i>	5 euros
	<i>dois vinténs</i>	40 <i>reais</i>	4 euros
	<i>índio</i>	33 $\frac{1}{3}$ <i>reais</i>	33.(3) euros
	<i>vintém</i>	20 <i>reais</i>	2 euros
	<i>meio vintém</i>	10 <i>reais</i>	1 euro
	<i>cinquinho</i>	5 <i>reais</i>	50 cents
Copper coins	<i>três reais</i>	3 <i>reais</i>	30 cents
	<i>real</i>	1 <i>reais</i>	10 cents
	<i>ceítal</i>	$\frac{1}{6}$ <i>reais</i>	1.(6) cents

Remarks

- Nominal value according the Laws of 20 November 1539 and 26 November 1548.
- Value at prices in the early 21st century, computed considering that today's price level is roughly 20,000 times higher than that of the early 16th century and 1 euro has the approximate nominal value of 200,000 *reais*.
- Coins marked with an asterisk were presumably commemorative, not actually circulating, because of their size (weight of 20 g or more) and exceptional minting.

had become possible to make payments for a large range of values without significant exchange trouble.

3. The Portuguese monetary system in the age of Brazilian gold

In the 16th century, Portugal was at its height as colonial (and European) power. Late in the century, however, it was made part of the Western Hapsburg Empire when Philip II also became King Philip I of Portugal in 1580. As a consequence, it had to sustain the

protracted conflict with the United Provinces of the Low Countries over its colonial empire. This ended with almost complete defeat in the Indian Ocean and the Far East but a rather favourable outcome in the Brazilian and African possessions of the Atlantic, which now became the core of the third Portuguese colonial empire. Meanwhile, Portugal separated from the Western Hapsburg Empire in 1640. During the 18th century the country enjoyed an epoch of renewed prosperity based on Brazilian gold strikes and exports of domestic wine. However, it failed to show any sign of modern economic growth.

These transformations naturally had monetary consequences, in particular the significant devaluation of the monetary unit to finance the war with the United Provinces in the colonies and the Western Hapsburg Empire in Europe, and the massive minting of gold coins in the 18th century. Nevertheless, all in all the Portuguese monetary structure around 1750 was not that greatly different from a quarter of millennium earlier (Table 3).

As a matter of fact, the set of means of payment did not change qualitatively between the 16th and the 18th centuries. There was a reduction of amplitude to 4200:1, as a consequence of the disappearance of the high-value prestige coins. The largest-denomination coin now had purchasing power of about 22 per cent of the average yearly per capita income, estimated at 57,000 *reais* at current prices and 1,200 euros today; the smallest coin had purchasing power of around 2 per cent of average daily per capita income, estimated at 157 *reais* at current prices and 3.30 euros today. There was an increase of density, with seventeen current denominations, a maximum ratio of the values of coins of successive denominations of 2.5:1, and a density indicator of 0.593.

4. Monetary instability and the gold standard

The prosperity and monetary stability of Portugal in the 18th century were brought to an end by the war with revolutionary and imperial France. French invasions of Portugal's continental territory

TABLE 3
Means of payment in Portugal around 1750

Minted coins	Name	Nominal value	Value at today's prices
Gold coins	<i>dobra de oito escudos</i>	12,800 <i>reais</i>	268.8 euros
	<i>dobra de quatro escudos</i>	6,400 <i>reais</i>	134.4 euros
	<i>dobra de dois escudos</i>	3,200 <i>reais</i>	67.2 euros
	<i>escudo</i>	1,600 <i>reais</i>	33.6 euros
	<i>quartinho</i>	1,200 <i>reais</i>	25.20 euros
	<i>meio escudo</i>	800 <i>reais</i>	16.80 euros
	<i>cruzado</i>	480 <i>reais</i>	10.08 euros
	<i>cruzadinho</i>	400 <i>reais</i>	8.40 euros
Silver coins	<i>doze vinténs</i>	240 <i>reais</i>	5.04 euros
	<i>seis vinténs</i>	120 <i>reais</i>	2.52 euros
	<i>tostão</i>	100 <i>reais</i>	2.10 euros
	<i>três vinténs</i>	60 <i>reais</i>	1.26 euros
	<i>meio tostão</i>	50 <i>reais</i>	1.05 euros
	<i>vintém</i>	20 <i>reais</i>	42 cents
Copper coins	<i>dez reais</i>	10 <i>reais</i>	21 cents
	<i>cinco reais</i>	5 <i>reais</i>	10.5 cents
	<i>três reais</i>	3 <i>reais</i>	6.3 cents

Remarks

- Nominal value according the Laws of 4 April 1722 and 7 August 1747.
- Value at the prices of the early 21st century, computed considering that today's price level is roughly 4200 times higher than that of the mid-18th century and 1 euro has the approximate nominal value of 200,000 *reais*.

(1807-1812) and its economic separation from Brazil (after 1808, when the Portuguese government was transferred there to escape French armies) brought a new means of payment, namely inconvertible paper money (from 1796 on) to finance military expenditure. In an effort to redeem the paper money, a bank of issue for convertible notes was instituted (in 1822). However, the political separation of Brazil and internal conflicts brought new political and economic troubles, with monetary consequences: the paper money was redeemed only during the 1830s, and monetary normalcy lasted just for a decade, as banknotes became inconvertible again in 1846. Not

until mid-century was a new political stability attained, economic prosperity restored, and a modicum of modern economic growth and monetary stability recovered, in the form of the gold standard (enacted in 1854). However, bank transfers failed to become a current means of payment, and the banknotes themselves were slow to penetrate current transactions, as the monetary upheavals of the first half of the century remained a fresh memory.

The following table summarizes the Portuguese monetary structure under the gold standard.

TABLE 4
Means of payment in Portugal around 1875 (bank transfers)

	Name	Nominal value	Value at today's prices
Banknotes	—	100,000 réis	1,600 euros
	—	50,000 réis	800 euros
	—	20,000 réis	320 euros
	—	10,000 réis	160 euros
	—	5,000 réis	80 euros
	—	2,500 réis	40 euros
Gold coins	<i>coroa de ouro</i>	10,000 réis	160 euros
	<i>meia coroa de ouro</i>	5,000 réis	80 euros
	<i>sovereign*</i>	4,500 réis	72 euros
	<i>half sovereign*</i>	2,250 réis	36 euros
	<i>quinto de coroa</i>	2,000 réis	32 euros
	<i>décimo de coroa</i>	1,000 réis	16 euros
Silver coins	<i>cinco tostões</i>	500 réis	8 euros
	<i>dois tostões</i>	200 réis	3.20 euros
	<i>tostão</i>	100 réis	1.60 euros
	<i>meio tostão</i>	50 réis	80 cents
Bronze and copper coins	<i>vintém</i>	20 réis	32 cents
	<i>dez réis</i>	10 réis	16 cents
	<i>cinco réis</i>	5 réis	8 cents
	<i>três réis</i>	3 réis	4.8 cents

Remarks

- Nominal value according the Law of 29 July 1854.
- Value at the prices of the early 21st century, computed considering that today's price level is roughly 3,200 times higher than that of 1875 and 1 euro has the approximate nominal value of 200,000 *reais*.
- The sovereign and half sovereign were British gold coins that had entered Portuguese payment habits and received legal tender status.

The existence of banknotes brought the amplitude of the means of payment to the highest value ever, at 33,333.(3):1, owing in particular to the creation of banknotes of very high value. The largest denomination now had purchasing power greater than average yearly per capita income, estimated at 89,000 *reais* at current prices and 1,425 euros today; and the coin with the lowest value had purchasing power equal to 1 per cent of average daily per capita income, estimated at 244 *reais* at current prices and €3.90 today. This implied a small decrease in density, with sixteen current denominations, a maximum ratio between successive denominations of 2.5:1, and a density indicator of 0.499.

5. Towards the last Portuguese monetary system

At the turn of the 1890s a financial crisis put an end to Portuguese prosperity, cut modern economic growth short, brought a new bout of political instability, and forced the abandonment of the gold standard (suspension of convertibility). The instability ultimately led to the overthrow of the monarchy, replaced in 1910 by a republican regime, which created a new Portuguese monetary unit, the *escudo*, with the conversion rate of 1 *escudo* = 1,000 *réis*. Hopes of restoring economic stability and the gold standard were dashed first by World War I, which triggered a staggering inflationary process that was not brought under control until 1924, later by the Depression (although here Portugal managed to escape the worst effects on the world economy) and World War II, when despite economic recession Portugal's formal neutral status allowed accumulation of significant international reserves. Only in the golden age following World War II did the Portuguese economy find its definitive way to modern economic growth.

Apart from inflation and the measures to control it, monetary evolution during this period presented some other interesting features. First, gold and silver gradually disappeared from minting, and even copper was partially superseded by new alloys. In World War

I and the post-war inflation, metallic coins fell out of circulation, as the rising prices of metals made it profitable to melt them down; for a while, low-denomination banknotes and scrip issued by the central government, local governments and even private entities flooded into circulation. After inflation was tamed, for a brief period the monetary system consisted in the international gold-exchange standard, with the pound sterling as anchor, but the collapse of this system and the suspension of sterling convertibility in 1931 brought Portugal into the so-called “sterling area.” The years after World War II, and then the 1960s and early 1970s, were marked by moderate inflation. After World War II, Portugal became first an informal and later a formal member of the Bretton Woods international monetary system, whose collapse in the mid-1970s accelerated the inflation that was already under way. It was brought under control in the late 1980s and 1990s in connection with Portugal’s adherence to the exchange rate mechanism of the first European Monetary System.

Participation in the process of European integration was limited at first. Portugal leaned towards simultaneous ties both to Europe and to the remaining colonial empire. Hence, Portugal opted for the European Free Trade Association and not the European Community as the preferred European trading bloc. Finally decolonization, in the wake of the crisis of the mid-1970s, allowed formal association with the European Community. Portugal became a member of the EC in 1986 and participated fully in the progressive steps in the formation of the European Economic and Monetary Union, notably the European single market (1993) and the single currency (1999).

Table 5 summarizes what we can call the last Portuguese monetary system.

In addition to bank transfers, the set of means of payment available just before the establishment of the European Monetary Union consisted in twelve denominations of banknotes and coins. The smallest denomination was out of use in practice, however, reducing current denominations to eleven. The ratio between the largest and smallest denominations was 10,000:1, the maximum ratio between successive denominations was 2.5:1, and the density indicator was 0.433.

TABLE 5
Means of payment in Portugal in the late 20th century (bank transfers)

	Name	Nominal value	Value at today's prices
Banknotes	—	10,000 <i>escudos</i>	50 euros
	—	5,000 <i>escudos</i>	25 euros
	—	2,000 <i>escudos</i>	10 euros
	—	1,000 <i>escudos</i>	5 euros
	—	500 <i>escudos</i>	2.50 euros
Coins	—	200 <i>escudos</i>	1 euro
	—	100 <i>escudos</i>	50 cents
	—	50 <i>escudos</i>	25 cents
	—	20 <i>escudos</i>	10 cents
	—	10 <i>escudos</i>	5 cents
	—	5 <i>escudos</i>	2.5 cents
	—	1 <i>escudo</i>	0.5 cents

Remark

- Value at early 21st century prices, computed using the approximate conversion rate of 1 euro = 200 *escudos*.

The ratio of the highest denomination to average yearly income (2,384,000 *escudos* at current prices in the 1990s and 11,920 euros at early-21st-century prices) was only 0.4 per cent, while the ratio of the smallest denomination to average daily income (6500 *escudos* at current prices in the late 1990s and 30 euros at early-21st-century prices) was only 0.015 per cent.

6. The European Monetary Union

In 1999 Portugal became part of the European Monetary Union. The *escudo* was replaced as monetary unit by the euro, with the conversion rate of 1 euro = 200.482 *escudos*.

The cash changeover in 2002 replaced banknotes and coins denominated in *escudos* with those denominated in euros. Since then, the means of payment available in Portugal have been identical to

those in the other members of the European Monetary Union, as summarized in Table 6.

TABLE 6
Means of payment in Portugal since 2002 (bank transfers)

	Name	Nominal value	Value at today's prices
Banknotes	—	500 euros	500 euros
	—	200 euros	200 euros
	—	100 euros	100 euros
	—	50 euros	50 euros
	—	20 euros	20 euros
	—	10 euros	10 euros
	—	5 euros	5 euros
Coins	—	2 euros	2 euros
	—	1 euro	1 euro
	—	50 cents	50 cents
	—	20 cents	20 cents
	—	10 cents	10 cents
	—	5 cents	5 cents
	—	2 cents	2 cents
	—	1 cent	1 cent

Remark

• Nominal value identical to value at early 21st century prices.

The new set of means of payment is broadly similar to its predecessor, with some minor exceptions, namely: (i) denominations larger than those previously issued were introduced, but they did not come to form part of spending habits; (ii) the smallest denomination was greater in value, but even so there is a tendency to exclude the smallest coins from current use.

Thus, the amplitude (ratio of largest note to smallest coin) increased to 50,000:1, while the maximum ratio between successive denominations remained at 2.5:1, and the density indicator came to 0.462. The ratio of the largest denomination to average yearly income rose to nearly 4 per cent, while that of the smallest coin to average daily income rose to 0.03 per cent.

Conclusions

An overview of the evolution of the sets of means of payment available through the history of Portugal as an independent state is given in Table 7. Three main points are worth making.

First, between the 12th and the 15th centuries the sets of means of payment issued by the Portuguese kings had narrow amplitudes, usually lower than 1000:1. The largest denominations ranged between 50 and 100 euros at today's prices and were equivalent to almost 20 per cent of average yearly income, the lowest denominations ranged between 5 and 20 cents at today's prices, still worth more than 5 per cent of average daily income. Densities were low, always fewer than ten denominations, maximum ratios between successive denominations of more than 10:1 and density indicators below 0.20. These characteristics indicate a poorly monetized economy.

Next, from the 15th to the 19th century, the sets issued by the monarchy had intermediate amplitudes, usually between 2000:1 and 10,000:1, with the largest denominations between 100 and 300 euros at today's prices and equivalent to just over 20 per cent of average yearly income, while the smallest denominations were worth between 1 and 10 cents at today's prices and equal to 1 to 5 per cent of average daily income. Densities were intermediate or high, always with more than ten denominations, maximum ratios between successive denominations less than 5:1 and density indicators slightly above 0.50. These characteristics indicate a significantly monetized economy.

Lastly, the means of payment issued from the 19th to the 21st century, first by the Portuguese state and then by the European Monetary Union, have large amplitudes, usually higher than 10,000:1. The largest denominations were worth more than 100 euros at today's prices, the smallest worth between 1 and 10 cents. And densities were high, always with more than ten denominations, maximum ratios between successive denominations no greater than 5:1 and density indicators usually between 0.40 and 0.50. These characteristics

of the sets of means of payment indicate that the economy was fully or almost fully monetized.

TABLE 7
Characteristics of the sets of means of payment in Portugal

Period	Around 1250	Around 1500	Around 1750	Around 1875	Around 2000	Early EMU
Yearly income, current prices	9 libras 3 soldos	8,000 reais	57,000 reais	89,000 réis	2,384,000 escudos	11,920 euros
Yearly income, early-21 st - century prices	400 euros	800 euros	1,200 euros	1,425 euros	11,920 euros	11,920 euros
Daily income, current prices	6 dinheiros	22 reais	157 reais	244 réis	6,500 escudos	32,65 euros
Daily income, early-21 st - century prices	1,10 euros	2,19 euros	3,29 euros	3,90 euros	32,65 euros	32,65 euros
Largest denomination, current prices	1,5 libras	4,000 reais	12,800 reais	100,000 réis	10,000 escudos	500 euros
Largest denomination, early-21 st -century prices	64 euros	40 euros	269 euros	1,600 euros	50 euros	500 euros
Smallest denomination, current prices	1 dinheiro	1/6 real	3 reais	3 réis	1 escudo	1 cents
Smallest denomination, early-21 st -century prices	17 cents	1.(6) cents	6.3 cents	4.8 cents	0.5 cents	1 cent
Largest denomination/ yearly income	0.160	0.500	0.225	1.12	0.004	0,042
Smallest denomination/ daily income	0.160	0.007	0.019	0.012	0.000 15	0,000 3
Amplitude	360	2,400	4266.(6)	33,333.(3)	10,000	50,000
No. of denominations	2	12	17	16	12	15
Density	0.003	0.493	0.593	0.499	0.433	0,462

The curve of the ratio between the value of the top denomination and average yearly income has had an inverted-U shape in the contemporary era. During the 19th century it rose to figures greater than 100 per cent as a consequence of the issue of high-denomination banknotes; and during the 20th century it declined to less than 10 per cent, owing in part to the widespread use of bank transfers instead of banknotes for large-value payments and in part to the increase in average income due to modern economic growth. The ratio of the

smallest denomination coin to average daily income held relatively stable during the 19th century and tended to decrease during the 20th, again owing mainly to the rise in average income. Note that bank transfers make the amplitude and the density of the values of available means of payment formally infinite, which we may consider to be a new characteristic of contemporary monetary systems.

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