New banknote and coin series

Formats, materials and colours

Report from the banknote and coin project

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Contents

A new Swedish banknote and coin series

The Riksbank has decided to renew the Swedish banknote and coin series. The main reasons for this are the need to upgrade the banknote series with new security details and the need to make coins smaller and lighter in order to reduce cash management costs and the environmental impact of the coins. At the same time a new denomination, 200 krona, will be introduced, and the 2-krona coin will be reintroduced. The coin series will consist of the denominations 1, 2, 5, 10 and 20 krona and the banknote series of the denominations 50, 100, 200, 500 and 1,000 krona.

The work on designing the new banknote and coin series has been conducted by a project organisation at the Riksbank in cooperation with the banks, cash management and cash-in-transit companies and trade associations in the retail sector. The project organisation is presented in Appendix 1. This report presents the steering group's proposals on formats, materials and colours. The General Council of the Riksbank's Drafting Committee for the Design of Banknotes and Coins has monitored and influenced this work on an ongoing basis and supports the proposals of the steering group.

The motifs for the banknotes and coins and the security system for the banknotes are dealt with in two other reports. The design of the banknote and coin series is thus described in three reports.

- New banknote and coin series – formats, materials and colours (this report)
- New banknote and coin series – themes and motifs
- Security system for the banknote series

Our colleagues at the European Central Bank (ECB) and at the central banks in Denmark, Finland, the Netherlands, Norway, Switzerland and the UK, as well as the Bavarian Mint, have contributed their advice and experience. The Riksbank's suppliers of coins and banknotes, Crane AB and Mint of Finland, have also provided advice and comments. Grontmij AB has been responsible for the environmental impact assessment. The Swedish National Laboratory of Forensic Science and the Swedish Theft Prevention Association have participated in the security assessments and the Swedish Association of the Visually Impaired has contributed with regard to adjustments for the visually impaired. Suppliers of equipment for the mechanical handling of banknotes and coins have provided advice on the practical consequences of the project's proposals. We owe a vote of thanks to all concerned for their highly valuable assistance.

For further information we refer to our previous reports "The use of cash in Sweden" (September 2008), "Examination of the need for a 50-öre coin" (November 2008) and "Denominations and their allocation among banknotes and coins – proposal for a review of the banknote and coin series" (February 2010). These reports are available on Sveriges Riksbank's website (www.riksbank.se).

Stockholm, March 2011

Christina Wejshammar
Chairperson of the steering group

Summary

The banknote series

In order to improve the efficiency of the handling and production of banknotes it is proposed that the format of the notes should be smaller than today and that all the banknote denominations should be of the same height. It is proposed that the height of the banknotes should be 66 millimetres. The lowest denomination, 20 krona, should be 120 millimetres long. The difference in length between the denominations should be seven millimetres. However, for technical reasons it is proposed that the difference in length between the 20-krona banknote and the 50-krona banknote should be six millimetres. The 20-krona banknote would thus have the format 120 x 66 millimetres while the format of the 1,000-krona banknote would be 154 x 66 millimetres.

It is proposed that the banknotes should be made of cotton paper that is stronger than that used in the current banknotes. It is also proposed that the lower denominations, 20 and 50 krona, which suffer the most wear and tear, should be made of a reinforced paper and possibly be varnished. As an aid to the visually impaired, it is proposed that the banknotes should have distinctive printed details that can be felt with the fingertips.

The proposal is that the colours should be same as those used in today's banknotes, with the addition of green for the new 200-krona denomination. The colours of the banknotes would thus be grey-brown (1,000 krona), red (500 krona), green (200 krona), yellow/orange (50 krona) and violet (20 krona). The shades of colour should be such that there is a clear contrast between the denominations.

The coin series

It is proposed that the new 1 and 2-krona coins should be made of copper-plated steel. A copper-plated steel coin consists of a steel core covered with a thin layer of copper. It is a light and inexpensive material that is durable and has a relatively low environmental impact. The 5-krona coin should be made of Nordic gold, which is the same material as in today's 10-krona coin. The present 10-krona coin will remain unchanged.

The new coin series will thus consist of two copper-coloured coins (1- and 2-krona coins) and two gold-coloured coins (5- and 10-krona coins). The coins will have milled edges to help the visually impaired to distinguish between the denominations.

The coins will be significantly smaller and lighter than today. The weight of the 1-krona coin, which is the most common coin, will be approximately half that of the present coin. The reintroduction of the 2-krona coin means that fewer 1-krona coins will be needed. The total

weight of the coins in circulation will fall by approximately 50 per cent following the implementation of the coin reform.

Economic consequences

The main benefits of the new banknote and coin series to society are better protection against counterfeit banknotes, lower handling costs and reduced environmental impact. However, replacing the banknotes and coins will also entail changeover costs for the cash market and the Riksbank. These costs mainly relate to transportation and storage, the conversion of equipment for the mechanical handling of banknotes and coins and the purchase of new banknotes and coins.

The Riksbank's purchasing costs for banknotes will not be significantly affected by the change, as the increased costs for security details will be compensated for by lower production costs. On the other hand, it is estimated that the purchasing costs for coins will fall by around 70 per cent.

The banknote series

Requirements regarding banknotes

Banknotes must meet many different requirements to function as an effective means of payment. The project has used the following six criteria when selecting formats, materials and colours for the new banknotes series:

- Protection against counterfeiting
- The possibility to quickly identify a genuine banknote
- The possibility to easily distinguish between different denominations
- The preconditions for cost-effective manufacture and cash management
- Durability
- Environmental impact

Protection against counterfeiting is mainly provided by the banknotes security details. In addition to this, the banknotes need to be designed so that, when paying, the public can easily and quickly identify a genuine banknote and its denomination.

The preconditions for cost-effective manufacture and cash management are mainly affected by the size of the banknotes and the quality of the banknote paper. The choice of paper quality also affects the durability of the banknotes and thus their lifetime.

The environmental impact of banknotes mainly arises in connection with extraction of the raw materials for the banknote paper and with the production of the banknotes. Transportation is another environmental factor and is affected by the number of banknotes in circulation.

Format

Starting points

The starting points when choosing formats are that it should be possible to distinguish between the banknotes and that the production and management of the banknotes should be efficient. At present, the management of banknotes at the banks, in the retail sector, at the cash-in-transit

companies and at the Riksbank is mainly handled mechanically, which means that the formats of the banknotes need to be adapted to mechanical processing to make management efficient.

It is appropriate for the size of the banknotes to vary with the denomination in line with the principle the higher the value the larger the note. Banknote formats can vary in both height and length or in length or height alone. The current Swedish banknotes grow in both height and length as the denomination increases, with the exception of the 50-krona note which has a different format.

Today, most of the major banknote printing works use printing sheets of the same format. The production of banknotes is most efficient when it is possible to use the printing sheets to the maximum. Banknotes are thus cheaper to produce if they are small and if the format is adapted to the size of the printing sheets. Reducing the size of the banknotes for the higher denominations may entail a cost saving of up to 20 per cent.

Height and length

The banks, the cash-in-transit companies and the suppliers of equipment for the mechanical handling of banknotes have unanimously said that the management of banknotes will be most rational if all the banknote denominations have the same height. The reason is that this will make it possible to adapt packaging, storage spaces and machinery to one and the same height. This will also increase efficiency in connection with printing. Another possibility would be for all the banknotes to have the same length and to vary the height depending on the denomination. However, this alternative is not as efficient in terms of production. For reasons of efficiency, it is therefore better for all the banknotes to be of the same height and to distinguish between them by giving them different lengths.

Our assessment is that the lowest appropriate height is 66 millimetres, which is one millimetre lower than the present 20-krona banknote. This is a height that provides a high level of production efficiency. It is proposed that the minimum length should be 120 millimetres; that is the same as the present 20-krona banknote.

The difference in length between the denominations needs to be approximately seven millimetres to make it possible to distinguish between them. The project has also found that production efficiency increases considerably if the difference in length between two of the banknotes is reduce to six millimetres. The printing sheets can then be used to the maximum. The project therefore proposes that the difference in length between the 20-krona banknote and the 50-krona banknote should be six millimetres, while it should be seven millimetres between the other banknotes. See Table 1.

Table 1: Proposal for the formats of the new banknote series, millimetres

Denomination	New banknote series	Present banknote series	Euro banknotes
20 krona	120 x 66	120 x 67	
50 krona	126 x 66	120 x 77	120 x 62 (5 euro)
100 krona	133 x 66	140 x 72	127 x 67 (10 euro)
200 krona	140 x 66		133 x 72 (20 euro)
500 krona	147 x 66	150 x 82	140 x 77 (50 euro)
1000 krona	154 x 66	160 x 82	147 x 82 (100 euro)
			153 x 82 (200 euro)

			160 x 82 (500 euro)

Source: The Riksbank

Recommendations, formats

- All the denominations should have the same height, 66 millimetres
- The lowest denomination, 20 krona, should be 120 millimetres long.
- The difference in length between the denominations should be seven millimetres, except between the 20- and 50-krona banknotes where the difference should be six millimetres.

Materials

Starting points

The project has evaluated three types of material:

- Cotton paper
- Polymer
- Combinations of cotton paper and polymer

The advantages of cotton paper are that it provides good printing quality and that it is a relatively inexpensive material. The disadvantage is that it is less resistant to dirt and moisture, which means that banknotes for denominations that are used frequently wear out quickly. The paper manufacturers have therefore developed different methods to reinforce banknotes made of cotton paper. These include mixing polymer materials into the pulp and varnishing the banknotes after printing. Cotton paper is the most common material in banknotes in the world and there are a large number of manufacturers. The Riksbank has long used cotton paper in the Swedish banknotes and it is used by all the neighbouring countries.

The advantage of polymer banknotes is that they are more resistant to dirt and moisture. Polymer also makes it possible to use security details that are specially adapted to polymer materials. The disadvantage is that the print can wear out relatively quickly and there are indications that the banknotes tear easily if they are creased or crumpled. Polymer is more expensive than cotton paper but this is offset by an increase in the lifetime of the banknotes. At present there is only one supplier of polymer banknotes in the world, the Australian company Securency. According to this company, polymer banknotes are used in 17 countries in the world, usually countries with a warm climate and/or major counterfeiting problems. The only country in Europe that has polymer banknotes is Rumania. Canada intends to changeover to polymer banknotes.

There are several types of material that combine polymer and cotton paper. One example is a hybrid paper manufactured by the German company Louisenthal. This paper consists of a core of cotton paper between laminated outer layers of polymer. The project has also evaluated a new

type of paper developed by the Swiss company Landqart AG. This paper consists of a core of polymer between laminated outer layers of cotton paper. The advantage of this material is that it retains the characteristics of cotton paper but is more durable. This material is not used by any central bank as yet.

Reinforced paper

The Riksbank has experience of a reinforced cotton paper developed by Crane Currency that uses a technique called Anti Soiling Treatment (AST). This entails mixing a polymer material into the pulp. This paper has been in use for a few years in the 20-krona banknote and Denmark uses it throughout the new Danish banknote series. Other paper manufacturers offer materials that are similar to AST. The project has commissioned strength tests in which banknotes have been artificially subjected to wear and tear in a laboratory. These tests show that AST banknotes are more durable than banknotes made from ordinary cotton paper. However, reinforced banknote paper is more expensive. It may therefore be most appropriate to use such paper in banknote denominations that suffer a lot of wear and tear.

Another way to extend the lifetimes of banknotes is to coat them with a dirt-resistant varnish after printing. The project has consulted the central bank in the Netherlands which had varnished banknotes in its national banknote series from 1957 up to the introduction of the euro in 2002. Their experience is that varnishing considerably extends the lifetime of the banknotes. It is important, however, to use a type of varnish that will stand up to rough treatment and that works together with the paper used. Other central banks say that in their experience varnishing does not work very well and may even shorten the lifetime of the banknotes. Varnishing entails extra costs.

Today's Swedish banknotes are printed on paper with a weight per unit area of 85 grammes per square metre. Many countries, including the euro countries, use a heavier paper with a weight of 95 grammes per square metre.

Security ink dyes

The cash-in-transit companies have made substantial investments in security systems that are used to counteract robberies. These systems include security cases in which the banknotes are stained with security ink dye if the cases are damaged. The use of the ink-dye technique is now a demand from the National Police Board. The ink-dye system is also used in the cassettes of ATMs, cash-operated fuel pumps etc. and in some types of security cabinet. It is therefore important that the material used in the banknotes functions together with the security ink dyes. The banknotes must be effectively dyed and it must be difficult to wash out the dye.

The project commissioned the Swedish Theft Prevention Association to test the effect of the security ink dyes on several different types of paper. These tests were carried out at the Swedish National Laboratory of Forensic Science in 2010. Three of the four security ink dyes that are certified in Sweden were tested. The supplier of the fourth dye chose not to take part, but has only a small part of the market. Five types of banknote paper were tested: ordinary cotton paper, AST paper without varnish, AST with a water-based varnish, AST paper with UV-hardened varnish and the new Swiss laminated paper made from cotton/polymer. The properties tested were the susceptibility of the paper to the security ink dyes and the ability to retain the dyes when attempts are made to wash them out.

The results showed that the ordinary cotton paper and the Swiss laminated paper had the best properties. Very few of the notes would be serviceable after determined attempts to wash out the

dyes. The results for AST paper without varnish were somewhat poorer, while the results for varnished banknotes were much poorer. It would be possible to use a large proportion of the varnished banknotes after washing. The results were particularly poor for banknotes treated with UV-hardened varnish. Polymer banknotes were not included in the test, but all the indications are that the effect would be the same as for varnished banknotes, that is the effect of the ink dyes would be much weaker.

The results show that varnished banknotes cannot be introduced in Sweden with the current types of varnish and dye. However, there is information from other central banks to indicate that there may be ways of solving the dyeing problems relating to varnished banknotes. At present, however, it is unclear how far the development of these methods has progressed and whether they would work on the Swedish market.

Another lesson learned from the tests is that the dyeing effect works better on light surfaces than on dark surfaces. Parts of the edges of the banknotes should therefore have a light surface so that the effect of the security ink dyes can be clearly noted. This will be taken into account when designing the banknotes.

Selection of materials

The fact that all the indications are that the security ink dyes have a limited effect on polymer materials, together with the fact that there is only one supplier, argues against polymer materials. Introducing polymer banknotes would also represent a break with a long Swedish tradition of cotton paper banknotes. Nor does the design of the security details justify the introduction of polymer banknotes. Although polymer banknotes are more durable, polymer also entails major disadvantages.

The new Swiss material that combines polymer and cotton paper is an interesting technique in that the banknotes retain the characteristics of cotton paper. However, the central bank that chooses to be the first to introduce this material must expect to participate in the final development work together with the supplier. The project therefore believes that this material is only of interest in the longer term.

The project recommends that the Riksbank should keep cotton paper in the new banknote series. However, a stronger paper is needed to apply the new security details that the project proposes. A stronger paper will also help to improve durability. The aim should be to increase the paper's weight per unit area to 95 grammes per square metre.

The denominations below those used in ATMs etc. are those that suffer the most wear and tear. There are therefore good reasons for using a reinforced paper in the 20- and 50-krona banknotes. The indications are that reinforced paper, possibly in combination with varnishing, would lead to savings as the banknotes would last longer. The aim should be to print the 20- and 50-krona notes on AST paper, or an equivalent material, and to coat them with varnish, providing that varnishes and security ink dyes are available that would work in the ink-dye security system. The time remaining until new banknotes have to be ordered should be used to investigate which material is appropriate and if it is possible to use varnish.

It should be pointed out that the problems relating to worn 20- and 50-krona banknotes will not be solved by improving the quality of the banknotes. Although the lifetime of the banknotes will increase, the problems relating to wear will remain as long as the retail sector keeps the banknotes in circulation too long.

Aids to the visually impaired

The visually impaired find it difficult to distinguish between the denominations on the basis of the size of the banknotes alone. Special details are therefore needed in the paper that can be felt with the fingertips and that are unique to each denomination.
The project has arranged for the production of samples of such details which have been inspected by representatives of the Swedish Association of the Visually Impaired. The details need to be printed in intaglio so that they can easily be felt and do not wear out. The new banknotes therefore need to have intaglio print that also includes part of the banknotes' edges and corners.

The visually impaired have also requested that the denomination of the banknotes should be clear. The numbers should be large and there should be a clear contrast between the colour of the numbers and the background colour. The denominations should also be clearly distinguished from each other. These views will be taken into account when designing the banknotes.

Recommendations, materials

- The banknotes should be made of cotton paper
- A stronger paper than that used today should be used
- The 20- and 50-krona banknotes should have extra reinforcement and varnishing should be investigated
- The banknotes should carry special details in intaglio print for the visually impaired.

Colours

Starting points

When a new banknote series is designed, an effort is made to use clear colours and contrasts so that the banknotes can quickly be identified and distinguished when paying. The colours in the new banknote series should therefore be more distinct than today. However, the banknotes should not be entirely in one, plain colour and the colours should not be perceived as glaring. The proposed colours should be seen as principle colours that act as a starting point for the design of the banknotes. The exact shades will be determined in connection with the final design.

Choice of colours

When the euro banknotes were designed, the ECB conducted a survey based on studies of how people perceive different colours. The aim was to achieve clear contrasts between the denominations and to make counterfeiting more difficult. It was noted, among other things, that

purple is the most difficult colour to counterfeit. The euro countries therefore chose purple for their highest denomination, 500 euro. In addition, the Swedish National Laboratory of Forensic Science (SKL) has noted that the use of yellow makes it more difficult to trace the source of counterfeit banknotes. The euro has seven banknote denominations, which in principle means that the complete colour spectrum is used. The colours are used as follows:

Denomination	Colour
500 euro	Purple
200 euro	Yellow-brown
100 euro	Green
50 euro	Orange
20 euro	Blue
10 euro	Red
5 euro	Grey

An alternative for the Swedish banknote series is for the colours to follow the same principle as for the euro banknotes. The highest denomination, 1,000 krona, would then have the colour that is most difficult to counterfeit, that is purple. However, the next highest euro denomination, 200 euro, is yellow, that is a colour that should be avoided according to SKL. The 500-krona banknote should therefore be red instead. This would mean the following colours: purple (1 000), red (500), green (200), orange (100), blue (50) and grey (20). This would result in clear colour contrasts, especially between denominations where there is a risk of confusing one for the other.

Another alternative is that the colours of the Swedish banknotes and the euro banknotes should correspond for banknotes of approximately the same value. This means that the 1,000-krona banknote would have the same colour as the 100-euro banknote, the 500-krona banknote the same colour as the 50-euro banknote and so on. The advantage would be that this would simplify the use of both of the currencies. However, one argument against such an arrangement is that the Swedish banknotes will have a completely different design to the euro banknotes, so using corresponding colours would not necessarily have any decisive effect on how the banknotes are perceived.

A third alternative is to keep the colour scale of the present banknote series. This is the alternative advocated by the General Council's Drafting Committee for the Design of Banknotes and Coins. The group believes that there is a value in maintaining a tradition from the present banknote series and that it will make things easier for the public if the colours are the same. It is proposed that the new denomination, 200 krona, should be green. It is also emphasised that a sober shade of colour should be aimed at.

The project's view is that the most important criterion is that there are distinct colour differences between the denominations. This applies especially to denominations where there is a risk of confusion; that is between the 1,000- and 100-krona banknotes, the 500- and 50-krona banknotes and the 200- and 20-krona banknotes. There should also be clear differences between denominations that are close to each other. The project's assessment is that it is possible to achieve such contrasts within the framework of the current colour scale by issuing directives in connection with the design of the banknotes. Against this background, the project recommends that the present colours should be retained and that the new 200-krona banknote should be green. See Table 2 and Figure 1.

Table 2: Proposed principle colour scale for new banknote series

Denomination	New banknote series	Present banknote series
1,000 krona	Grey-brown	Grey-brown
500 krona	Red	Red
200 krona	Green	
100 krona	Blue	Blue
50 krona	Yellow/orange…….. ……..	Yellow/orange…….. ……..
20 krona	Purple	Purple

Source: The Riksbank

Figure 1: Principle design of the banknote series. Approximately natural size

Recommendations, colours

The principle colours of the banknotes would thus be grey-brown (1,000 krona), red (500 krona), green (200 krona), yellow/orange (50 krona) and purple (20 krona).

The coin series

Requirements regarding coins

There are several basic requirements if coins are to function as an effective means of payment. It should be easy to identify the denominations, the coins must work in coin machines and automats and the coins must be distinguishable from those used in neighbouring countries. In addition there a number of other factors that need to be take into account when designing a coin series. The project has evaluated various types of coin on the basis of the following five criteria:

- Protection against counterfeiting
- Durability
- Purchasing price
- Environmental impact and health risks
- Weight

Coins can be easier or more difficult to counterfeit depending on the design and the material used. As counterfeit coins are unusual in Sweden and the value of the coins is low, the level of security does not need to be exceptionally high. This applies above all to the lower denominations where the risk of counterfeiting is smallest.

The hardness of metals varies. This means that the durability of the coins varies depending on the alloy used. The evaluated alloys are well tried and tested and the project's assessment is that their durability is good, although there are differences. In general, coins have a long lifetime.

The purchase price depends on the metals included in the alloys used and on the design of the coin. Prices vary depending on the current prices for metals on the world market. In order to ensure that the value of the metal does not exceed the nominal value of the coin, the purchase price must be significantly below the nominal value. The applies especially when a new coin series is designed as the difference between the purchase price and the nominal value will decrease as a result of inflation.

Different metals have a different environmental impact depending on supply, extraction methods and the potential for recycling. Smaller and lighter coins help to reduce the environmental load as a lower quantity of raw materials is used and transportation is simpler. The working environment for those who have to handle coins in the course of their work is also improved. One health issue that the project has devoted particular attention to is the risk of nickel allergy.

The weight of the coins is a decisive factor in determining the cash management costs to society as a whole. The weight is mainly determined by the size of the coin. In order to achieve the objective of reducing the weight of the coins, the coins in the new series must therefore be smaller than those in use today.

Materials

Starting points

The material in coins may consist of a single metal or of an alloy. Metals and alloys can be combined in different ways and result in different types of coin. There are three common types of coin – homogeneous coins, plated coins and bi-metal coins. Homogeneous coins have the same metal or alloy throughout the coin. Plated coins consist of an homogeneous metal or alloy as a core and an outer layer of a single metal. Bi-metal coins consist of a metal or alloy centre and an outer ring of another metal or alloy.

There are also coins that are built up of layers of metals or alloys. The current 5-krona coin has such a structure and consists of layers of copper and nickel. This is a complicated technique that makes the coin difficult to counterfeit, but also expensive.

Homogeneous coin

Plated coin

Bi-metal coin

The project has evaluated three homogeneous and two plated coins. In order to get an idea of the appearance of the coin series if a coin of a higher denomination is introduced in the future, the project has also commissioned the design of a bi-metal coin.

Homogeneous coins

The following types of homogeneous coin have been evaluated:

- Copper-nickel coins
- Copper coins
- Coins of Nordic gold

Copper-nickel coins normally consist of an alloy of 75 per cent copper and 25 per cent nickel. The nickel component gives the coins a silver colour. The advantages of copper-nickel are that it is durable, difficult to counterfeit and easy to recycle. It is also aesthetically attractive due to its silver colour. However, nickel has environmental and health disadvantages. Products that contain nickel can trigger contact allergies and the handling of nickel in production processes may entail health risks. Nickel allergy is a health indicator in Sweden's environmental objectives for a toxic-free environment. Copper-nickel is now an expensive material due to the high prices for copper and nickel on the world market. Copper-nickel is a common coin material around the world, but is declining in importance due to the metal prices. The current 1-krona coin is an example of an homogeneous copper-nickel coin.

The current 1-krona coin: 75 % copper, 25 % nickel.

Copper coins often consist of an alloy of copper, zinc and tin. Historically, copper has been the most commonly used material in coins around the world alongside gold and silver coins. Sweden has had many copper coins. The latest was the 50-öre coin that became invalid in 2010. The advantages of copper are that it is relatively durable and easy to recycle. However, copper coins are easier to counterfeit than many other coins because the material is common in commercial products. Copper coins also have a tendency to darken over time. Copper prices have increased in recent years, which has increased the prices of copper coins.

The earlier 50-öre coin: 97 % copper, 2.5 % zinc and 0.5 % tin.

Nordic gold coins consist of an alloy of 89 per cent copper, 5 per cent aluminium, 5 per cent zinc and 1 per cent tin. The coins thus mainly consist of copper but are gold coloured. The name

"Nordic gold" comes from the fact that the alloy was originally developed in Sweden by the Swedish Mint and the company Gränges Metallverken. The aim was to produce a durable material that did not contain nickel. The material is now in use in several countries. Examples of Nordic gold coins include the current Swedish 10-krona coin and the 10-, 20-, and 50-cent coins in the euro countries. The price of the material is similar to that of copper coins.

10-krona coin in Sweden and 20-cent coin in the euro countries: Nordic gold: 89 % copper, 5 % aluminium, 5 % zinc, and 1 % tin.

Plated coins

The following materials have been evaluated:

- Copper-plated steel
- Nickel-plated steel

A copper-plated steel coin consists of a steel core covered with a thin outer layer of copper. More than 90 per cent of the coin consists of steel but the coin is copper coloured as a result of the copper plating. The largest component of steel is iron, which is in good supply and is easy to extract, produce and recycle. The environmental impact of steel is therefore lower than that of many other metals. Other advantages are that the coins are light and inexpensive to produce. They are also regarded as being relatively durable. Examples of copper-plated steel coins include the 1-, 2- and 5-cent coins in the euro countries.

Nickel-plated steel coins consist of a steel core covered with a thin outer layer of nickel. They are made in the same way as copper-plated coins but are silver coloured as a result of the layer of nickel.

5-cent coin in the euro countries: Copper-plated steel coin.

Bi-metal coins

Bi-metal coins have the advantage that they are difficult to counterfeit and that their appearance signals a high value. They are relatively expensive to purchase and are used for higher denominations. Examples include the 1- and 2-euro coins. The project has commissioned the design of a test coin of copper-plated steel and Nordic gold. This is a combination that provides a durable and light coin with a limited environmental impact. Such a coin would be appropriate if a new coin of a higher denomination is introduced in the future.

1 euro coin: Bi-metal coin: Combination of copper, nickel and brass.

Prototype of a bi-metal coin. Combination of copper-plated steel and Nordic gold.

Allergy risks

Nickel allergy is caused by lasting and repeated skin contact with objects that give off nickel such as jewellery, watches and spectacle frames. Nickel is the most common cause of contact allergies among both children and adults. According to scientific studies, 17 per cent of the women and three per cent of the men in Sweden are allergic to nickel. Some 30 to 40 per cent of those with a nickel allergy develop hand eczema, which often becomes chronic.

A 1994 EU directive stipulates limits for the leakage of nickel from certain products that come into direct and lasting contact with the skin. This directive came into force in 2000 and has been incorporated into Swedish legislation in the form of instructions from the Swedish Chemicals Agency. However, these regulations do not cover coins or tools. The reason for this is that it is considered that objects of this type are not as significant causes of nickel allergy as, for example, jewellery and other personal items. However, people with a nickel allergy also risk developing hand eczema from lasting contact with objects that contain nickel but are not covered by the EU's directive.

Professor Carola Lidén of Karolinska Institutet in Stockholm has published a large number of scientific studies on nickel allergy. Some of these studies relate to the release of nickel and skin exposure from coins. The project has consulted Professor Lidén and examined her results. The studies show that several coin alloys that contain nickel give of significant quantities of nickel to the skin already after relatively brief contact. The effect increases as the duration of the exposure increases. This applies to the current 1- and 5-krona coins, as well as to other types of copper-nickel coins. Professor Lidén's conclusion is that coins made from alloys that give off nickel on contact with the skin always entail a risk of nickel allergy. Coins made using nickel-free alloys, which have also been investigated, do not constitute an allergy risk.

Professor Lidén's studies were one of the reasons why copper-nickel was not chosen as an alloy in the euro coins. Instead, copper-plated steel coins are used for the lowest denominations and Nordic gold is used for the intermediate denominations. Nickel is used, however, in the 1- and 2-euro coins.

Choice of materials

Nickel should not be used in the new coins because of the allergy risk. Nickel is also at a disadvantage in terms of cost. A consequence of not using nickel will be that the new coins will not be silver coloured. One alternative for getting silver-coloured coins could be to use stainless

steel. This is an unsuitable material, however, as it is very hard and thus difficult to mint coins from and stainless steel coins would also cause a lot of wear to coins made from other materials when handling coins.

The project's assessment is that copper-plated steel coins represent the most appropriate type of coin for the low denominations. They are light, environmentally-friendly and inexpensive. The fact that these coins are easier to counterfeit than other types is of limited importance considering their low value. The fact that copper darkens in the course of time is a disadvantage from an aesthetic point of view, but this has previously been accepted for copper coins for low denominations, for example the 50-, 5- and 1-öre coins. Nordic gold is a suitable material for intermediate denominations. It is a durable material that signals a high value due to its yellow colour. Bi-metal coins are suitable for high-denomination coins.

Which coins should be designated as low-, intermediate- and high-denomination coins depends on the number of coins in the coin series and their value. In the project's view, the 1- and 2-krona coins can be classified as low-denominations and the 10-krona coin as an intermediate denomination. The 5-krona coin can be designated as either a low or intermediate denomination. There will be no high-denomination coins in the coin series. Consequently, the coins in the new coin series should be made of copper-plated steel and Nordic gold.

Recommendations, materials

- Low denomination coins should be made of copper-plated steel and intermediate denominations of Nordic gold.

The design of the coin denominations

Starting points

Low weight is the most important factor for improving the efficiency of the management of coins in society. On 31 December 2010, there were approximately 1.9 billion coins in circulation. 72 per cent of these were 1-krona coins. Consequently, it is most important to reduce the weight of the 1-krona coin. It is expected that the new 2-krona coin will eventually become one of the most common coins, so this coin should also have a low weight. The proportion of 5- and 10-krona coins in the total amount of coins is much less, so the weight of these coins is not as important. See Table 3.

Table 3: Number of coins in circulation on 31 December 2010 and the denominations' proportion of the total amount of coins

Denomination	Number of coins, millions	Proportion of total, per cent
1 krona	1 340	72
5 krona	261	14
10 krona	254	14

Source: The Riksbank

In order to avoid the risk of one coin being confused with another in connection with mechanical handling, all of the coins must have different formats. In addition, none of the coins should have the same format as one of the present denominations. For the same reasons, the

coins must also differ from the coins used in Sweden's neighbouring countries. The proposals presented below have different formats to the existing Swedish coins and to the coins in circulation in the euro countries and in Denmark, Latvia, Lithuania, Norway and Poland.

The designs have also been checked with the leading Swedish suppliers of equipment for the mechanical handling of coins. This includes the sealed cash register system used in the retail sector. With the proposed design of the coins it will be possible, in the assessment of the suppliers, for the machines to distinguish between the present and new Swedish coins and between Swedish coins and those from neighbouring countries.

The market will be offered test series of the new coins for testing in coin machines before the coins are put into circulation. If such tests show that problems still remain in distinguishing between the denominations, then adjustments will be made.

Design of individual coins

The present 10-krona coin is a relatively modern, low-weight coin made from Nordic gold. It well meets the requirements regarding a coin of an intermediate denomination. There is thus no reason to change the design of the coin and thus increase the changeover costs. The project therefore recommends that the 10-krona coin be retained in its present form. There will, however, be new coins for the 1-krona, 2-krona and 5-krona denominations.

The new coins must function for many years and a long perspective is therefore needed that takes into account the fact that their value will gradually decline as a result of inflation. The purchase price should therefore be low when they are introduced. Both the 1-krona coin and the 5-krona coin have a high purchase price today and they are also heavy in relation to their value. The 1-krona coin has had the same weight, seven grammes, since 1942.

The project proposes that the new 1-krona coin should be made of copper-plated steel and have a diameter of 19.50 millimetres. With a thickness of 1.79 millimetres the coin will weigh 3.60 grammes. It is proposed that the 2-krona coin should also be made of copper-plated steel and be a slightly larger coin with a diameter of 22.50 millimetres. With a thickness of 1.79 millimetres the coin will weigh 4.80 grammes.

The project proposes that the 5-krona coin should be somewhat larger than the 2-krona coin with a diameter of 23.75 millimetres and a thickness of 1.95 millimetres. This coin could be made either of copper-plated steel or of Nordic gold. The differences mainly relate to the counterfeiting risk and to price. A Nordic gold coin is more difficult to counterfeit than a copper-plated coin. However, the purchase price of a Nordic gold coin is almost twice as high. Apart from these factors there are also aesthetical concerns, for example that copper-plated coins tend to darken after a period of use.

The Swedish Trade Federation and some of the suppliers of equipment for handling coins have said that they prefer a 5-krona coin made of Nordic gold. The reasons are that it is more difficult to counterfeit this material than copper-plated steel, that there would be a clearer difference between the 2-krona and 5-krona coins and that Nordic gold coins are more durable.

The project notes that there is a price difference but that it is relatively small in relation to the Riksbank's total costs for the purchase of coins. The difference between the purchase price and the nominal value is also considerable in the Nordic gold alternative. Although counterfeit coins are unusual it is an advantage that Nordic gold coins are more difficult to counterfeit. A Nordic

gold coin also keeps its colour and surface quality better. Given this background, the project recommends that the 5-krona coin should be made of Nordic Gold. The proposal for the new coin series is presented in Table 4 and Figure 2.

Table 4: Proposal regarding materials, diameters and thicknesses in the new coin series and weight comparisons between new and present coins

Denomination	Materials	Diameter mm	Thickness mm	Weight grammes	Weight today grammes
1 krona	Copper-plated steel	19.50	1.79	3.60	7.00
2 krona	Copper-plated steel	22.50	1.79	4.80	14.00
5 krona	Nordic gold	23.75	1.95	6.10	9.50
10-krona (same)	Nordic gold	20.50	2.90	6.60	6.60

Source: The Riksbank

Figure 2: Principle design of the coin series. Approximately natural size.

Milling

The visually impaired may find it difficult to distinguish between the denominations on the basis of the size of the coins alone. Milling the edges of the coins in a way that is unique to each coin will therefore provide an important aid. A proposal regarding milling has been drawn up in consultation with the Swedish Association of the Visually Impaired.

The proposal is that the milling on the edge of the current 1-krona coin should be retained on the new 1-krona coin, which means that the entire edge is milled. The 2-krona coin should be milled in a way similar to the 20-cent coin of the euro countries; that is with a sparse but distinct milling. The project proposes that the 5-krona coin should, as today, be manufactured with a smooth edge. The 10-krona will retain its current milling with four milled fields. This solution entails clear differences between the denominations and that the milling on the 1- and 5-krona coins will be the same as today.

Consequences for weight

The project has carried out an assessment of the consequences for the weight of all coins in circulation following the replacement of coins in accordance with the proposal above. The total number of 1- and 2-krona coins is assumed to be 25 per cent less than the present number of 1-krona coins, as fewer coins will be needed after the introduction of the 2-krona coin. It is also assumed that only 80 per cent of the current coins will need to be replaced with new coins, as a portion of the coins currently in circulation will probably have been lost. The result is that the weight of coins in circulation will be decreased by just over 50 per cent, which is equivalent to about 7 000 tonnes. See Table 5.

Table 5: Weight of coins in circulation on 31 December 2010 and estimated weight after coin reform

Denomination	**1 kr**	**2 kr**	**5 kr**	**10 kr**	**Total**

Number of coins 31 Dec 2010, millions	1 340	-	261	254	1 855
Present weight, tonnes	9 380	-	2 480	1 676	**13 536**
Number of coins after reform, millions	408	408	209	254	1 279
Weight after coin reform, tonnes	1 469	1 958	1 275	1 676	**6 378**

Source: The Riksbank

Recommendations for design of coin denominations

- The 1-krona coin should be made of copper-plated steel with the format 19.50 x 1.79 millimetres
- The 2-krona coin should be made of copper-plated steel with the format 22.50 x 1.79 millimetres
- The 5-krona coin should be made of Nordic gold with the format 23.75 x 1.95 millimetres
- The 10-krona coin should remain unchanged and should be made of Nordic gold with the format 20.5 x 2.9 millimetres
- The coins should be provided with milled edges as an aid for the visually impaired

Economic consequences

Background

The cash system forms an important part of the payment system. At the same time, the management of cash is a costly process. There is thus reason for the Riksbank and other participants to continually draw attention to the efficiency of cash management and to look for solutions to reduce costs. The production and management of cash also has a link to environmental and health aspects. In addition, security is a central factor that often sets the standard for which solutions are possible.

Changes in banknotes and coins always entail changeover costs. These primarily arise among participants that handle cash in their work, such as banks, the retail trade and cash management companies. Consequently, the Riksbank mainly works with gradual changes and very seldom carries out fundamental reforms of the entire banknote and coin series. The present banknote series was introduced in the 1980s. For a long time, the coin series has only been changed through successive minor adjustments, primarily in the form of the abolition of lower denominations.

However, simultaneous changes can help to decrease changeover costs, as changeovers of machines and other equipment, information campaigns and other measures can be carried out at one and the same time. Occasionally, therefore, situations arise in which it is advantageous to make several changes at once. The Riksbank's assessment is that it would now be most rational to carry out a fundamental reform instead of recurring minor changes. Cash market participants generally prefer that changes are carried out simultaneously and over a short time span.

Socio-economic gains

The socio-economic gains of the new banknote and coin series consist of three parts:

- Better protection against counterfeiting
- Lower handling costs

- Reduced environmental load

The primary gain to be made from the new banknote series is that protection against counterfeit notes will be improved. The aim is to continue to keep counterfeits at such a low level that confidence in banknotes is not jeopardised. More widespread banknote counterfeiting could lead to confidence problems for the cash system and thus to major costs for society. In addition to the improved counterfeit protection, the number of banknotes will be decreased as a result of the introduction of the 200-krona banknote. The smaller format of the banknotes will also lead to rationalisation gains in cash handling.

The primary gain to be made from the new coin series is that transportation and handling costs will be reduced as a result of the lower weight of the coins. Furthermore, the number of coins will be decreased as a result of the introduction of the 2-krona coin. Environmental impact will be decreased due easier transportation and the reduced extraction of raw materials. The materials used in the new 1- and 2-krona coins also have a lower environmental impact than those used in the current 1- and 5-krona coins. The fact that nickel will no longer be used will also mean reduced health risks.

These effects can be described schematically as follows:

Factor/effect	Banknote series	Coin series
Counterfeit protection	Decreased counterfeit risk due to new security details	No change
Handling	Cheaper transportation and storage due to fewer banknotes and smaller format	Cheaper transportation and storage due to fewer and lighter coins
Environmental impact	Reduced environmental impact from production and handling due to fewer and smaller banknotes	Reduced environmental impact from production and handling due to fewer and lighter coins. Reduced health risks due to removal of nickel.

The cash market

The cash market will have lower handling costs as a result of the new banknote and coin series. The most significant effects will be a decrease in the number of banknotes and coins, and that coins will become lighter. However, this change will also entail changeover costs. These will mostly arise in three areas:

- The transportation and storage of the banknotes and coins to be withdrawn
- The distribution of new banknotes and coins
- The conversion of equipment for the mechanical handling of banknotes and coins

The changeover will mean that new banknotes and coins will be distributed from the Riksbank to the banks and the retail trade, at the same time as the currently-existing banknotes and coins will be returned to the Riksbank for destruction. Consequently, there will be considerably more transportation during the changeover period and storage requirements will increase. The greatest cost will arise if the currently-existing 1- and 5-krona coins are declared invalid and are withdrawn. This will involve large volumes of coins that will require comprehensive transportation and storage capacity.

There are many different types of machine and system that handle banknotes and coins, including ATMs, cash-handling systems in the retail trade, sorting machines in cash management

companies and banks, and various types of vending machine. All of this equipment must be adapted to the new design of banknotes and coins, as well as being adjusted to the denominations 200 and 2 krona. During a transition period, the cash system will have to handle double versions of the present banknote denominations and of the 1- and 5- krona coins.

The number of ATMs is presently about 2 400. According to information from suppliers, the number of closed cash-handling systems in the retail trade can be estimated at 12–14 000.

To minimise costs, the changeover will take place in close cooperation between the Riksbank and cash market participants. Consultations have been initiated with Bankernas Depå AB, the banks, the retail sector, cash management and cash-in-transit companies and manufacturers of the relevant machinery. As far as is possible, the Riksbank will adjust the rate of implementation to the market's wishes. The Riksbank is also planning a comprehensive public information campaign.

The Riksbank

Banknotes

At present, the Riksbank purchases banknotes to an average value of about SEK 43 million per year, calculated according to 2011 prices. The unit price is affected by the number of banknotes ordered on each occasion. Higher volumes mean lower unit costs, while lower volumes mean higher unit costs.

The new, smaller format will make the banknotes cheaper. At the same time, the more advanced safety details will mean price increases. The improvement of paper quality will also mean price increases, but this will be offset by the banknotes lasting longer. Costs will also be affected by the expansion of the banknote series with a 200-krona banknote, which will reduce demand for 100-krona banknotes.

The overall effect of these changes will be that the Riksbank's purchase costs will largely remain unchanged compared with the situation at present. The smaller format and the decreased number of banknotes will compensate for the increased costs of the increased security standard and the production of an additional denomination. See Table 6. In the calculation, the total number of 100- and 200-krona banknotes has been estimated to be 25 per cent lower than the current number of 100-krona banknotes. The number of 100- and 200-krona banknotes has been assumed to be the same. It is estimated that the improvement of paper quality will increase the lifetimes of 20- and 50-krona banknotes by 30 per cent.

Table 6: Cost comparison of current and new banknote series. Annual cost. 2011 prices.

Effect/denomination	20	50	100	200	500	1000	Total
Purchase costs, current banknotes, SEK millions	5	4	17		12	5	43
Purchase costs, new banknotes, SEK millions	5	4	8	10	12	5	44

Source: The Riksbank

Coins

At present, the Riksbank purchases coins to an average value of about SEK 49 million per year, calculated according to 2011 prices. The purchase costs of the new coin series will primarily be affected by the lower prices for the new coins. At present, a 1-krona coin costs about SEK 0.80, compared with about SEK 0.20 for the new coin. At present, a 5-krona coin costs about SEK 1.50, compared with SEK 0.58 for the new coin. The new 2-krona coin will cost about SEK 0.25 and the 10-krona coin SEK 0.61. In addition, the 2-krona coin will have the effect of reducing the number of coins. The result will be an estimated reduction of about 70 per cent of the Riksbank's annual purchase cost. This is equivalent to SEK 32 million. See Table 7. The real outcome will depend upon public demand for coins and current metal prices.

Table 7: Cost comparison of current and new coin series. Annual cost. 2011 prices.

Effect/denomination	1 kr	2 kr	5 kr	10 kr	Total
Purchase cost, current coins, SEK millions	32	-	12	5	**49**
Purchase cost, new coins, SEK millions	3	4	5	5	**17**

Source: The Riksbank

Replacement costs

The Riksbank's costs for the changeover will primarily consist of the purchase of new banknotes and coins. The costs of information campaigns, design, tests, storage and transportation can be added to this. The project has made an assessment of the economic consequences over a period of seven years, which is the length of time that the changeover will entail extra costs and income.

The basic assumptions are that the present 1- and 5-krona coins will be declared invalid and withdrawn, and that 50 per cent of the 1- and 5-krona coins in circulation will be returned to the Riksbank. It is furthermore assumed that the requirement for new coins will be equivalent to 80 per cent of the number of coins in circulation at present. It is presumed that the 2-krona coin and 200-krona banknote will reduce the number of coins and banknotes, in accordance with the assumptions presented above.

The result is presented in Table 8. The changeover is prepared during years 1-3. It is presumed that banknotes will be replaced during years 4-5, and coins in year 5. The estimated costs under these assumptions amount to SEK 633 million. The recycling of invalid 1- and 5-krona coins will provide a revenue of SEK 488 million. The net cost will thus be SEK 145 million.

Banknotes and coins that are not returned will be written off, having a positive effect on the Riksbank's net income. Coins will be written off in the year following invalidity, and banknotes ten years after invalidity. The size of this amount depends upon how many of the invalid banknotes and coins are not returned. For example, if 50 per cent of 1- and 5-krona coins are not returned, an amount of SEK 1 322 million will be written off and reported as revenue in year 6. If ten per cent of 20-, 50- and 100-krona banknotes and two per cent of 500- and 1 000-krona banknotes are not returned, an amount of SEK 2 943 million will be written off and reported as revenue ten years after year 5.

Table 8. The Riksbank's costs and revenue for the changeover of banknotes and coins if 50 per cent of 1- and 5-krona coins are returned. Excluding write-off of banknote and coin debts. 2011 prices. SEK million.

Effect/year	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Total
Purchase of banknotes			-108	-119				-227
Purchase of coins					-226	-80		-306
Other costs	-4	-15	-10	-19	-26	-18	-8	-100
Recovery of coins						+244	+244	+488
Total	**-4**	**-15**	**-118**	**-138**	**-252**	**+146**	**+236**	**-145**

Source: The Riksbank

Appendix 1. Project organisation

Steering group
Chairperson
Reference group
Consultants and suppliers
Project group
Project manager