ELECTRONIC MONEY AND

THE OPTIMAL SIZE OF MONETARY UNIONS

Cláudia Costa Storti
(Banco de Portugal)

Paul De Grauwe
(University of Leuven and CEPR)

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Introduction

The new information technologies (IT) promise to change the monetary landscape, creating new and more efficient payment systems. These new IT affect the monetary landscape in different ways. First, they lead to increasing international mobility of capital reducing the capacity of nation-states to insulate themselves from the rest of the world, and making it possible for individuals to quickly switch from the use of one national money to another. Put differently, the new IT is likely to increase the substitutability between existing national moneys. Second, they create new substitutes for traditional forms of money (cash). In particular, electronic money (e-money) may further reduce the importance of cash in the payments mechanism. Whether this will lead us to a "Cashless Society" in the foreseeable future is difficult to say. There is no doubt, however, that payments systems will move in the direction of a progressive reduction of the importance of cash. Third, the new IT create the possibility of the emergence of entirely new private payment systems that are parallel to the existing ones. It is not inconceivable that these new electronic payment systems drive out the existing publicly supported ones. These movements are likely to affect the boundaries of the existing national monetary areas.

The question we analyze in this paper is how the new IT are likely to affect the optimal size of monetary areas.

1. Money and network economics

One of the essential qualities of money is that it generates network externalities, i.e. the utility of money for any individual increases with the number of users. In this sense money is like a telephone network: expanding the size of the network increases the value of using the telephone to the original subscribers[1].

One of the major issues in network economics is how to internalise these network benefits so that these are fully exploited and so that the optimal size of the network is reached. In general it is accepted now that a competitive market system will not necessarily lead to the optimal size of the network (see Economides(1996))[2]. We will return to this issue because it constitutes the core of the theory of optimal currency areas. The issue we will want to analyse is whether the new IT can facilitate this process of internalisation of network benefits.

In Figure 1 we represent the network involved in the use of money. Each transaction necessitates the use of money. The service of money is provided by any issuer, B, (central bank, commercial banks or any other kind of company which decides to provide money). The users of the network are N_1, N_2, .. A transaction between N_i and N_j can be represented by N_iBN_j . The money network in Figure 1 is a two-way network and is formally equivalent to a telephone network. Adding another user to this monetary network increases the value of the network to the 6 original users.

Each issuer can be represented by a similar network as in Figure 1. Clearly there are gains to be made by the users of these different networks from merging these networks into one, a larger currency area. This however rarely happens (the exceptions being Belgium and Luxembourg during the second half of the 20^{th} century and the recent merger of the monetary networks in the European Union). We analyze in the next sections under what conditions such outright mergers are likely to occur.

What has happened much more frequently in monetary history is a partial merger of these different national networks. This has been achieved by making currencies convertible into one another. This was first done during the international gold standard when national currencies were convertible into gold at a fixed rate. In the language of network economics we can describe this process as follows. In the absence of convertibility, the different monetary networks are not compatible with each other. It is therefore impossible for a user of one network to make a monetary transaction with users of another network. This was the case in Europe during the 1950s. Convertibility of the national currencies has the effect of introducing compatibility between different networks (see Matutes and Regibeau(1992)). We show this in Figure 2.

There are now two issuers, B_1 and B_2. These provide monetary services to the members of their own networks. In addition, with convertibility, B_1 and B_2 are willing to convert their currency against the other (at a price charged to the user of this service). This is represented by the link between B_1 and B_2. It is now possible for N_i to make a transaction with M_j. This transaction is represented by $N_iB_1B_2M_j$.

This link-up of the two networks creates potentially large benefits for their users. These benefits, however, are smaller than those generated by an outright merger (a monetary union). The first reason is that the two moneys use a different numeraire making the valuation of the transaction more complicated. In addition the relative value of these numeraires (the exchange rate) can change and is thus inherently uncertain. Finally, the cost of the transactions between members of the two different networks is larger than the cost of the transactions between the members of the same network. Thus, the link-up of the two monetary networks represented in Figure 2 falls short of fully exploiting the network externalities. This can only be achieved by a monetary union (a full merger). The issue, however, is whether a full merger adds sufficient additional benefits compared to those achieved already through convertibility.

Figure 2 represents the situation of developed countries that have made their currencies convertible. The issue we want to analyze is whether the new IT has the capacity to strengthen networks of the type of Figure 2, so that outright mergers become less attractive.

2. The optimal size of a monetary network

It is useful to start from an analysis in which *individuals* in a closed economy face the problem of setting up a monetary network. Thus, we focus on the question of how e-money can emerge and provide for a new monetary network. We disregard the international context. This will be the focus of sections 4 and 5.

Consider N individuals. Each of them would benefit from being able to use the same payments network. We represent the willingness to pay for such a network as a function of the number of members in the network in Figure 3. More precisely the curve in Figure 3 represents the price, P, consecutive new subscribers to the network are willing to pay[3]. The existence of network externalities ensures that there is an upward sloping part to the willingness-to-pay curve, i.e. as the number of members increases, the value of the payments service increases so that consecutive new subscribers are willing to pay increasingly more for the network service. However the willingness to pay does not increase monotonically. In N_0 it reaches a maximum. As N becomes very large, consumers with increasingly lower willingness to pay must be attracted, offsetting the positive network effect[4]. Beyond N_0 we face the normal downward sloping demand curve. (Note that we have also drawn the corresponding marginal revenue curve, MR).

It should be stressed that the exact shape of the willingness to pay curve will also be influenced by the quality of the services provided in the network. This quality depends to a large degree on the capacity of the provider of the network to maintain monetary stability. We return to some aspects of this problem in section 6.

The cost structure in the supply of a monetary network is represented in Figure 4. We show the average and the marginal cost curves that are typical in the supply of monetary networks. Fixed costs are high and marginal costs are approximately constant. As a result, the economies of scale in the supply of a payments system are very large. Thus, economies of scale in the provision of payments systems occur both at the level of demand (due to network externalities) and supply. It should be stressed that we assume implicitly that monetary networks lack compatibility. We will come back to the issue of compatibility and we will argue that when monetary networks are compatible economies of scale in the supply can potentially be reduced.

The combination of network externalities in the demand and economies of scale in the supply has important implications for the market structure of monetary networks. We analyze these in Figure 5 where we combine the willingness to pay curve with the marginal cost curve. The Pareto optimal point is obtained in N_E where the price equals marginal cost. There is a coordination problem, though. Perfect competition is unlikely to sustain this optimal point. The reason is that the scale economies leave room for only a few profitable suppliers. Thus in the process towards N_E, few of the initial suppliers survive. The dynamics towards N_E will be characterized by frequent failures and collapses of payment networks. Since these are of crucial importance in economic activity, the process towards the optimum will be accompanied by great monetary and macroeconomic instability with great losses[5]. This is the fundamental reason why governments at some point got involved in the supply of a monetary network, either by taking it over and/or by regulating it.

All this should be kept in mind when thinking about the potential for new monetary networks to emerge from e-money. In short, there is no doubt that the private sector can supply new monetary networks. In fact, it could be argued that the new IT makes it easier for these to emerge. The reason is that it lowers the marginal cost of supplying the service. In addition, the ease of use for the subscriber to the network shifts the willingness to pay curve upwards. As a result, e-money increases the optimal size of the monetary network. The issue, however, is whether this can be done in an orderly way, avoiding collapses and crises with severe implications for the stability of the economy at large.

The previous analysis suggests that the emergence of new IT-based monetary networks will not be more successful than the private monetary networks of the past in providing these networks in a stable manner, because the basic economic structure of supply and demand of monetary networks has not changed by the introduction of new information technologies.

3. Compatibility and monetary networks

In the previous analysis we have left out one important aspect, i.e. the possibility that suppliers of network services emerge who promise to make the use of their network compatible with other networks. This feature of compatibility can be achieved by promising to make the liabilities of the network provider convertible into another monetary network. This possibility transforms the network into one with the structure of Figure 2. It also has the important implication that each individual supplier, even if relatively small, can capture a part of the network externalities. In other words, convertibility removes the need for individual suppliers to achieve a large scale in order to capture the benefits of the network externalities. We illustrate this in Figure 6. Assume that one or several monetary networks are in existence. A new supplier now emerges to sell network services, which include compatibility with the existing network services. As a result, the willingness to pay schedule faced by this new provider (P') has shifted to the left (relative to the willingness to pay curve, P, for the existing monetary network), i.e. the first subscribers enjoy large network benefits and are therefore willing to pay more than if they subscribed to a network without this compatibility feature. Thus, the network provider is able to achieve profitability at a lower scale of operation. It also follows that with compatibility the market can in principle reach an equilibrium with many profitable suppliers of monetary networks.

In the previous discussion we did not specify whether the convertibility is to be guaranteed at a fixed or at a flexible price (exchange rate). It is important to make this distinction. If convertibility is guaranteed at a variable price (exchange rate) the benefits gained from linking the networks will be lower than if convertibility is guaranteed at a fixed and credible price (exchange rate). In the latter case, the link to another network generates more value to the subscriber, because the future value of "joining the club" is known in advance (there is no risk that the value of linking the networks declines with time). As a result, he will be willing to pay more for the network service, than if the link with another network occurs at a variable exchange rate. Graphically, when conversion occurs at a fixed exchange rate, the shift in the willingness to pay curve to the left is more pronounced than in the case of conversion at a variable exchange rate. As a result, fixed price convertibility in principle allows for a larger number of small producers of networks.

The problem with the fixed price convertibility, however, is the credibility of such a commitment. Economic theory and history have shown that these commitments have a low credibility. Sooner or later, they lead to crises and collapses of the fixed exchange rate regime. Much of the benefit of the monetary network is lost.

Within the nation-state this problem has typically been solved by state regulation of individual banks, vastly increasing the credibility of the fixed price conversion of each individual bank. The issue can be raised whether state regulation was really necessary, and whether self-regulation could not have been used. The fact is that in practically all countries state regulation has been the main instrument. This can be used as *prima facie* evidence of the difficulties for markets to apply self-regulation.

4. E-money, compatibility and monetary networks

How does e-money affect the picture drawn in the previous sections? There are essentially two ways e-money can affect the existing monetary networks. First, the new information technologies should facilitate compatibility. For example, an Internet firm could create its IOUs to be used for payments. If it does this, using the dollar as a unit of account and promising to convert these IOUs in “real” dollars at par, its IOUs can easily gain acceptance in payments with very small conversion costs. The elimination of distance and other sources of transaction costs will make it easy for individuals to access this new money wherever it is created. In this sense the new technologies can create new payments instruments, “piggybacking” on the existing traditional payments systems.

If the new e-money takes the form just described, a proliferation of new monetary instruments becomes possible. However, the credibility problem will still loom large. The fact that compatibility is made easier technically has no bearing for the credibility of these commitments.

A second possibility is that the new information technologies lead to the creation of new payments systems bypassing the existing national monetary networks. Thus the IOUs created by our Internet firm are expressed in a new unit of account without a promise attached to it of conversion at a fixed price. Such a development is inherently more difficult to lead to success because of the nature of network economics. As argued earlier, the combination of economies of scale and of network externalities necessitates the development of a network with sufficient size. The existence of national payments systems will at least initially work as an obstacle for the development of alternative networks with sufficient size. Such a development, however, is not to be excluded in the long run. Further technological improvements in information technologies may make these alternative payments systems so cheap that they become serious competitors to the existing national payments systems.

The success of the development of alternative monetary networks critically depends on credibility. Thus, if electronic money provided by, say, Internet firms, is to make inroads into the existing monetary networks, the credibility of these firms must be established. This will only be possible with time (each firm builds its own credibility history) or if issuing firms are subjected to the same kind of supervision and regulation as the traditional providers of monetary services (the traditional banks)[6].

From the previous discussion we conclude that the development of electronic money could affect the future trends in payments systems in two very different ways. In a first scenario it could lead to completely new payments systems that bypass the national payments systems, and that may even lead to the latter's disappearance. In this scenario the nation-states loose their grip over the monetary networks. The national payment systems disappear and are supplanted by private payments systems because of the latter's superior technological efficiency. This scenario could be characterized by turbulence and monetary instability for the reasons described earlier. It is quite likely that after the turbulence only a few private monetary networks are left over. There will be no national impediments preventing the private networks to expand so as to fully use the benefits of network externalities. In the end it is quite likely that in this scenario the monetary networks will be much larger than the national networks in existence today. The question that remains to be analysed is how the movement towards private payments systems that supplant the national ones can be realised without endangering price stability. We return to this issue in the next section.

The second scenario looks very different. In this scenario, the new ITs lead to e-moneys that piggyback on the existing national payments systems. In this case, the increased ease of compatibility is the driving force. As a result, the national moneys remain in place and form the basis for the expansion of substitute moneys. This leads to the question of whether the new ITs may not lead to political incentives for countries to look for more (or less) monetary cooperation. We analyze this issue in the section 6 where we ask the question of whether the emergence of e-money will change the optimal dimension of national currency areas.

5. Monetary stability and the private supply of payment systems

As argued earlier, the new IT has the potential of leading to the emergence of private monetary networks that supplant the existing national ones. This is also a movement into a cashless society. We analyze how the new IT and the ensuing movement towards a cashless society will affect monetary stability[7].

The new IT has the potential of creating new monetary networks that are not based on cash and which are not under the control of national monetary authorities. Let us for the sake of the argument assume that new privately supplied monetary networks emerge as a result of the new IT. The problem with privately supplied money is well-known. It lacks a mechanism that ties down nominal variables like the money stock and the price level. This problem has been analyzed in great detail by economists (see Patinkin(1965), Fama(1980), Woodford(1999)). It can be formulated as follows. The value of the assets of the banks depends on the present and expected future price levels. When the price level is expected to increase the nominal rate of return on these assets increases, thereby increasing their nominal value. The present and future price levels in turn depend on the supply of money. The latter consists of the liabilities of the banks. This leads to a potential self-fulfilling price bubble in a system lacking an outside nominal anchor. An expectation of high nominal returns increases the value of the bank's assets, which raises the liabilities of the bank. Since the liabilities of the banks represent money, the higher money stock validates the expectation of a higher price level in the future. Thus without an outside nominal anchor there is no mechanism that prevents the price level from drifting upwards[1].

The issue now is to what extent the central banks will be able to perform their function of providing a nominal anchor in a world where an increasing amount of money is privately supplied and not based on cash. It can be argued that in such a

[1] Nominal anchoring can be done by targeting the money stock. Alternatively an "aggressive" Taylor rule performs the same trick (see Woodford(1999) on this).

"cashless society" the central banks will find it increasingly difficult to control the nominal money stock and the nominal interest rate (see Friedman(2000), Costa and De Grauwe(2001))[8]. As a result, the price indeterminacy problem may become more acute, leading to greater monetary instability.

This is likely to lead to the following scenario. Some issuers will be more successful than others in maintaining monetary stability (for instance, designing outside institutions capable of dealing with the new IT-induced monetary developments). These issuers are likely to act as magnets on other less successful private issuers. New monetary unions may then arise around these successful firms.

Whether these developments will increase the optimal size of monetary unions is difficult to say. Much will depend on the capacity of the international community to create new institutions capable of dealing with the potential instability generated by the emergence of privately supplied and cashless monetary networks.

6. Optimal currency areas

The second scenario looks quite different. As we argued earlier in this second scenario the publicly supported national monetary networks remain firmly in place and provide the basic collective support for new forms of money, like e-money. The issue that arises now is whether the new IT will give incentives to national governments to move into larger (or smaller) monetary unions.

In order to analyse this issue, we apply our model of network externalities to a different environment. Instead of being individuals, our basic units are now countries. Within each country a unified monetary network exists. Thus, in each country the coordination problem inherent in setting up a monetary network has been solved by giving the state a prominent role in it. The question at hand is whether it is profitable to merge these national networks into a bigger supranational network, and how this can be done. Again we will ask the question whether the emergence of the new IT changes the nature of the problem.

We use a model that is very similar to the previous one. Let's start assuming that countries are of equal size. (When countries are of different size the analysis gets complicated because the benefits from joining a network then depend not only on the number of members but also on the size of these members).

In Figure 7 we draw the willingness to pay curve, which looks very similar to the one used in the previous section. It is assumed that the issuers involved (which are countries) have already achieved a partial merger of their monetary networks through the device of convertibility (see our discussion related to Figure 2). Thus, the willingness to pay curve expresses the willingness to pay for a full merger, given the existence of a partial merger of national monetary networks.

The cost analysis is quite different from the analysis of individual agents. The reason is that each of the countries involved uses its own national monetary network as the basis to conduct monetary policies. These are aimed at stabilizing the economy in the face of shocks. To the extent that these shocks are idiosyncratic, the merger into a larger union reduces the capacity of each individual issuer to control the "monetary policy" of the aggregate. This should be seen as a cost of belonging to a supranational monetary network. This cost is assumed to increase with the size of the supranational monetary network. We show this feature in Figure 7 by an upward sloping marginal cost curve, i.e. each addition of a new member increase the risk of adopting a non stabilizing monetary policy.

Put differently, when another issuer joins while the network is small it can have some influence on the monetary policy of the network, so that the loss of the individual monetary policy is less costly than for an issuer joining the network that is already large. Note that asymptotically the MC curve stabilizes at some fixed number, i.e. when the network becomes very large the difference in the MC with successive additions of members becomes very small. Note also that the MC curve starts at point B on the y-axis. This reflects the fixed cost of operating the supranational monetary network, over and above the fixed cost of operating the national networks[9].

The Pareto optimal size[10] of the monetary union is given by N^* in Figure 7. We now turn to the question of how the new IT is likely to affect this optimum. We analyze first how the new IT affects the willingness to pay curve, and second how it affects the MC-curve.

Our claim is that the new IT shifts the willingness to pay curve downwards, as shown in Figure 8, so that the optimum size of the monetary union declines from N^* to N^{**}. This may seem paradoxical. It can be explained as follows. We have stressed that we analyze issuers that have achieved a partial merger of their monetary networks, in the way shown in Figure 2. The new IT is likely to affect the way this partial merger functions. In particular it is likely to facilitate the conversion (increase the compatibility) of currencies that are linked up. To give an example, the new IT makes the use of e-money much easier in international transactions. Whereas in the past, consumers traveling abroad had to exchange currency or carry travelers' checks, which were costly operations, they can now pay directly using their computer. In addition, the capacity of individuals to order goods and services through Internet and paying with cards, are technological innovations that have increased the compatibility of the national currencies, thereby making the link-up of different national monetary networks less costly. The result is that the additional network benefits to be obtained from a full merger of these networks declines. The willingness to pay for a fully merged network declines, and the optimal size of the monetary union declines.

The question that arises here is how important this decline in the willingness to pay for a full merger is likely to be. The main difference between the full merger of two monetary networks and the partial one depicted in Figure 2 is that in the latter case it is difficult to make a credible commitment of convertibility at a fixed price. In the case of a full merger this commitment is fully credible. Technical innovations in information technologies do not affect this difference. As a result, even if technically improved, the partial merger will not fully exploit the benefits of network externalities. Put differently, as long as there exists uncertainty about the exchange rate at which the two moneys in the partial merger can be converted, the move to a full union is a significant one. The technical improvements in compatibility may be of second order. It also follows that the downward movement of the willingness to pay curve may also be of relatively little importance.

How does the new IT affects the MC curve in Figure 8?

One aspect of the new IT is that it increases the size and the speed of capital movements. This has the effect of reducing the capacity of issuers to stabilize their supply. This holds both for fixed exchange and floating exchange rate systems. In the former case increased capital mobility makes the fixed exchange rate more exposed to self-fulfilling speculative attacks (see Obstfeld(1996)), leaving the fixed exchange rate regime more fragile.

In a floating exchange rate regime the volatility of the exchange rate reduces the capacity of the national monetary authorities to maintain domestic monetary stability. This is likely to be the case especially in small regions (see von Furstenberg(2002) on this issue).

We conclude that, whether the pre-union situation was characterized by fixed or flexible exchange rates, the new IT is likely to reduce the cost of a monetary union, thereby shifting the MC-curve downwards. This effect then increases the optimal size of the monetary union.

Thus, the new IT has opposite effects on the optimal size of monetary unions. There is a presumption that the downward shift of the MC-curve may be the most important effect. As we argued earlier, the downward shift of the willingness to pay curve may be rather small, because of the weak credibility of the fixed exchange rate systems. Thus, we arrive at the conclusion that the new IT is likely to increase the optimal size of a monetary union[11].

Conclusion

Is the new IT going to affect the optimal size of monetary unions? The answer, not surprisingly is: It depends. We distinguished two possible future scenarios. In a first one, the new IT lead to new and privately supplied payment systems that supplant the existing publicly supported ones. If this scenario materializes, it is likely to lead to monetary areas that are significantly larger than the present ones. We argued, however, that this scenario is bound to lead to much monetary turbulence. The political issue here is how national authorities will react to these developments. Within the nation state this problem was solved by letting the national law do the coordination. The same problem exists at the international level. The movement towards the larger monetary areas cannot easily be organized in the absence of government action, for the same reasons as apply within the nation-state. In order to move towards larger monetary zones, governments may have to solve the coordination problem. This remains true even in a world of internet and electronic money.

In a second scenario, the new IT "piggyback" on the existing national monetary networks. We analysed how in this scenario the new IT create incentives for nations to join in monetary unions. By increasing the technical efficiency of the payments systems, the new IT makes the conversion of one money into the other easier. As a result, the existing monetary networks are made more compatible with each other and the attractiveness of full monetary unions declines. The optimal size of monetary unions declines.

However, we argued that this effect is likely to be small relative to two other effects of IT. First, the new IT is likely to reduce the capacity of individual countries (especially the small ones) to build credibility about its stabilization purposes. As a result, relinquishing these instruments by joining a monetary union becomes less costly. Second, we argued that the new IT has the potential of weakening the credibility of fixed exchange rate regimes. If that is the case, the desire to move to larger monetary areas could actually increase. Thus, on the whole the new IT may very well increase the optimal size of monetary unions.

Figure 1: The monetary network

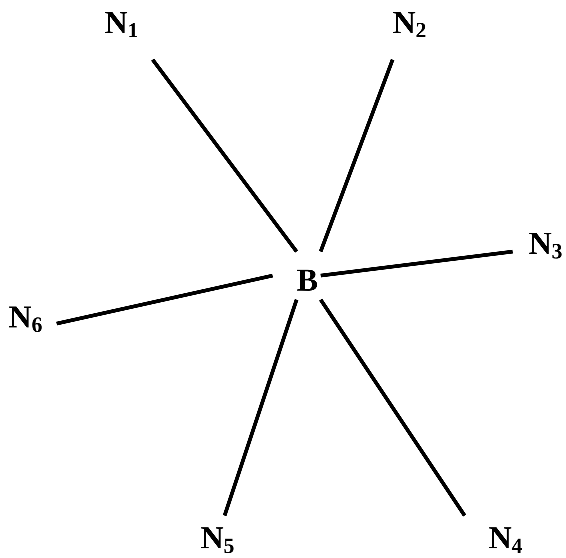


Figure 2: Partial merger of two monetary networks

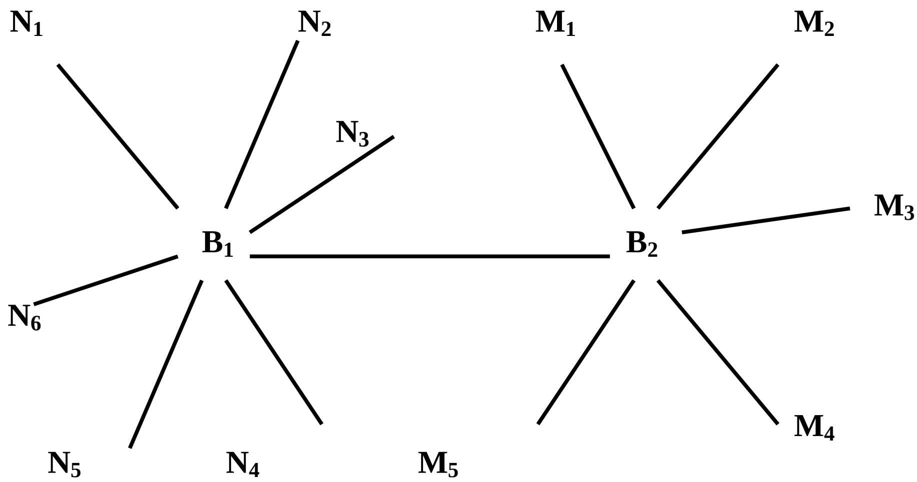


Figure 3: Willingness to pay curve

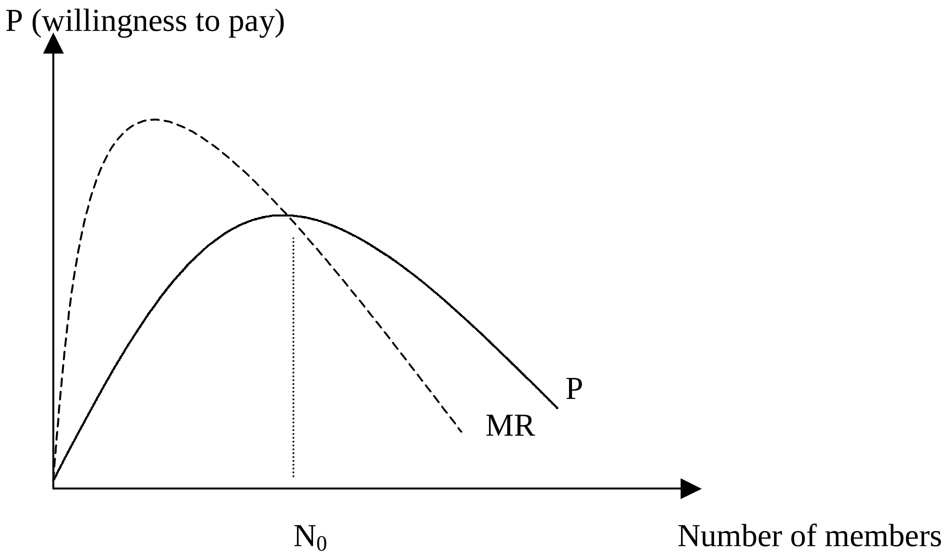


Figure 4: Average and marginal costs of network

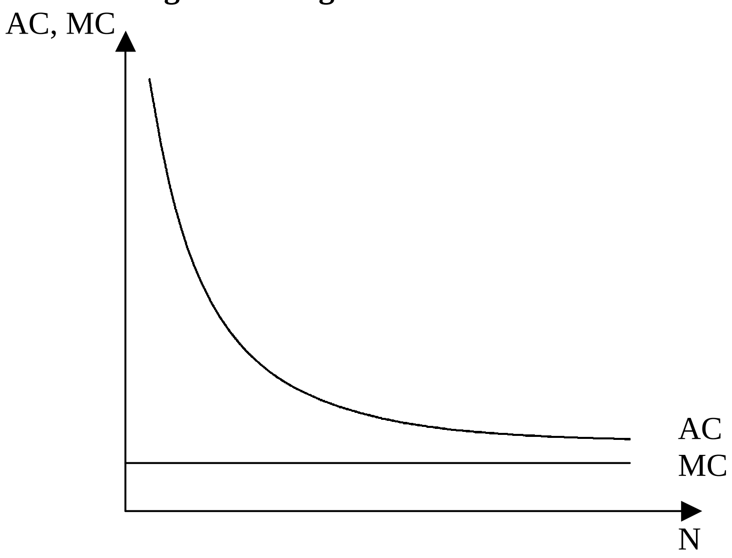


Figure 5: Optimal size of network

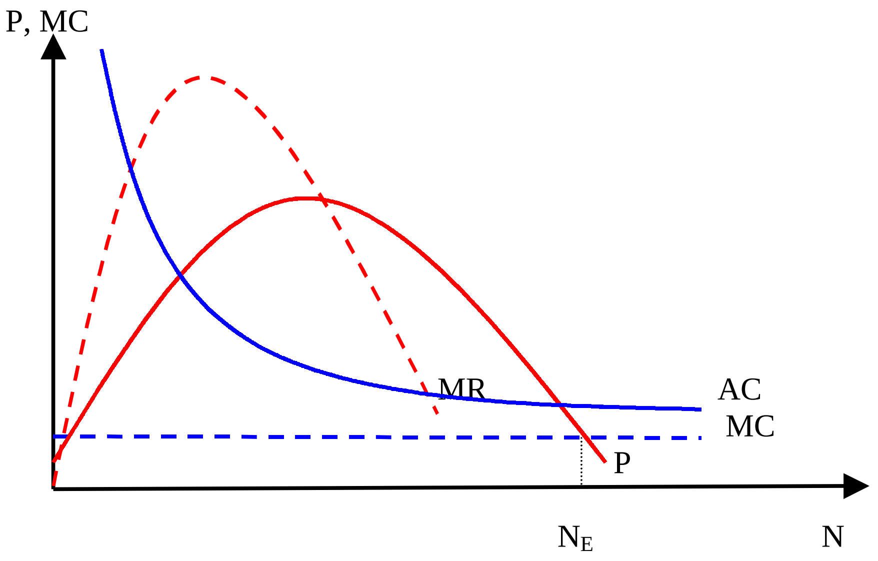


Figure 6

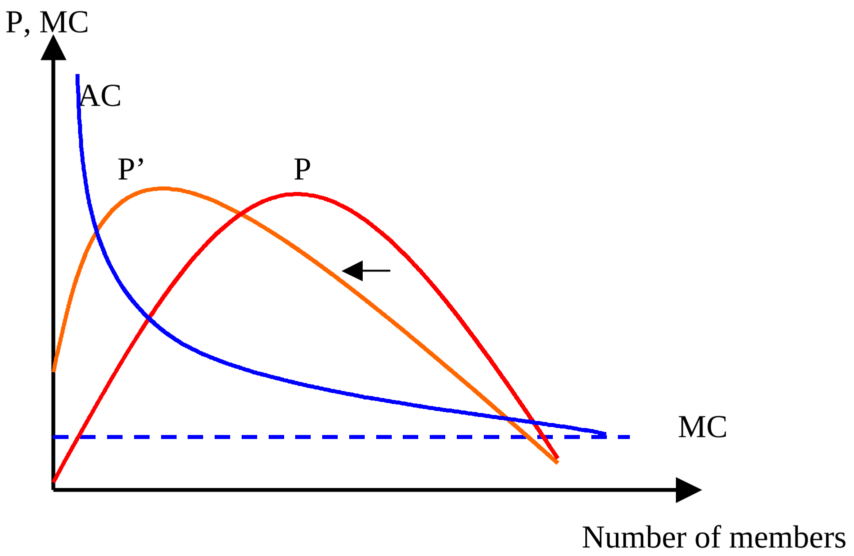


Figure 7: Optimal size of monetary union

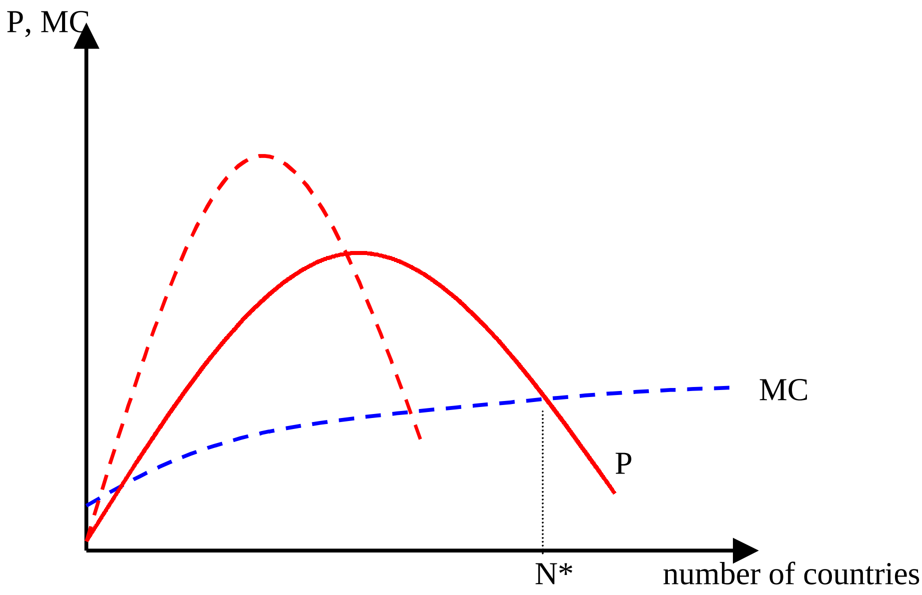
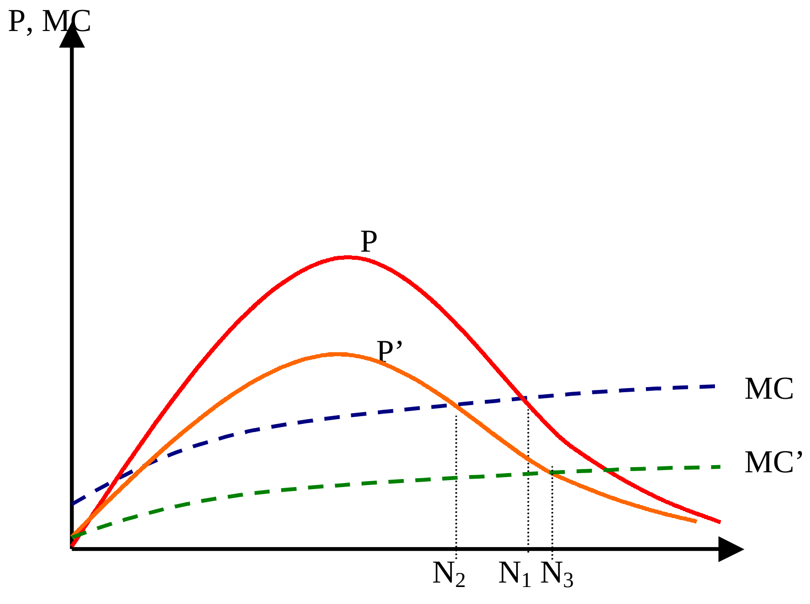


Figure 8: Effect of IT on optimal size of monetary union



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[1] There is sometimes confusion between network externalities proper and pecuniary externalities. The latter can easily be internalised by the market by price changes. The network externalities that are considered here cannot easily be internalised by competitive market forces. See Liebowitz and Margolis(1994) on this issue.

[2] Although there is wide consensus about this, there is also dissent. The dissent is based on the analysis of Hayek(1978). See also Klein(1974).

[3] Note that the n –the subscriber expects the network to be of the size n (see Economides(1996) on this.

[4] See Economides(1996) for a derivation of this willingness to pay line.

[5] The classic reference of the inherent fragility of a banking system is Diamond and ().

[6] There is an important issue here of how supervision and regulation should be organised. Some aspects of supervision can be performed by private institutions, e.g. rating agencies. We do not go into the issue here what the role is of public and private institutions in supervision and regulation.

[7] Much of the discussion in this section is based on Costa and De Grauwe(2001).

[8] For a dissenting view, see Goodhart(2000) and Woodford(2000). These views are discussed in Costa and De Grauwe(2001)).

[9] There are many complications underlying the marginal cost curves. For example, some countries peg their exchange rate; others allow the exchange rate to float. The latter loose more when joining a monetary union than the former. This affects the shape of the MC-curve. Note that the fixers also experience a cost when joining a monetary union for the simple reason that they loose their ability to change the exchange rate in the face of an asymmetric shock.

[10] We call this the Pareto optimal size of the monetary union because it is the point where the price the last member is willing to pay equals the marginal cost. It is also the point that maximises the net benefit of the monetary union.

[11] A similar conclusion is reached by von Furstenberg(2001). See also Cohen(2000).