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10.9.1997

## A Model of Common Monetary Policy

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The views expressed are those of the author and do not necessarily coincide with the views of the Bank of Finland.

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# A Model of Common Monetary Policy

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## Abstract

This paper analyses the prerequisites for and the results of unanimous monetary policy decisions in a monetary union consisting of heterogeneous members. The analysis is based on a multicountry version of Rogoff's model of the determination of monetary policy in the presence of supply shocks. It is shown that an international transfer system can be designed which creates consensus both on the average rate of inflation and the common response to asymmetric shocks to the participating economies. We conjecture that this kind of transfer mechanisms, institutionalized or informal, supporting joint decisions tend to evolve in contexts where there is strong aversion of disagreement. Monetary policy is arguably such a context, because frequent disagreement within the decision-making body could be harmful to credibility.

The transfer system capable of supporting consensus on monetary policy can be based on activity-related, automatic subsidies for countries which would individually prefer lower inflation rates, and activity-related taxes for countries which would prefer higher inflation in absence of the transfer system.

It turns out that the common monetary policy created by unanimous decisions under the supporting transfer mechanism can be characterized as a weighted average of the national "stand-alone" inflation rates, i.e. the rates which would prevail without the monetary union. The weights of the countries are not related to the sizes of the national economies, but rather to the national attitudes towards inflation and transfer income. Countries with a low stand-alone rate of inflation get a large weight in the determination of the common monetary policy, as do the countries which have a relatively low marginal valuation of international transfer income.

Keywords: Positive inflation theory, monetary union, monetary policy

# Yhteisen rahapolitiikan malli

## Suomen Pankin keskustelualoitteita 15/97

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Tutkimusosasto

### Tiivistelmä

Tutkimuksessa tarkastellaan yksimieliseen päätöksentekoon perustuvan rahapolitiikan edellytyksiä ja seurauksia rahaliitossa, joka koostuu erilaisista jäsenistä. Tarkastelu perustuu Rogoffin esittämään malliin rahapolitiikan määräytymisestä taloudessa, jossa esiintyy tarjonta- eli kustannushäiriöitä. Osoitetaan, että voidaan laatia kansainvälinen tulonsiirtojärjestelmä, joka luo rahaliiton jäsenten kesken yksimielisyyden sekä keskimääräisestä inflaatiouvahdista että yhteisen rahapolitiikan reaktioista epäsymmetrisiin häiriöihin. Tällaisia yhteisymmärrystä tukevia tulonsiirtomekanismeja, institutionalisoituja tai epämuodollisia, saattaa hyvin kehittyä yhteyksissä, joissa erimielisyyttä pyritään voimakkaasti karttamaan. Rahapolitiikan voidaan katsoa olevan esimerkki tästä, koska toistuva erimielisyys rahapoliittisia päätöksiä tekevissä elimissä voisi vahingoittaa politiikan uskottavuutta.

Rahapoliittista konsensusta tukeva kansainvälinen tulonsiirtomekanismi voidaan perustaa tuotantosidonnaisiin, automaattisiin tukipalkkioihin maille, jotka erillisinä suosisivat matalaa inflaatiota, ja tuotantosidonnaisiin veroihin maille, jotka irrallaan rahaliitosta harjoittaisivat korkeaan inflaatioon johtavaa rahapolitiikkaa.

Osoittautuu, että tulonsiirtomekanismin varassa yksimielisesti päätettyä rahapolitiikkaa voidaan luonnehtia keskiarvona maiden erillisinä ajamista rahapolitiikoista, kuitenkin siten, että maiden asenteet inflaatiota ja kansainvälisiä tulonsiirtoja koskien määrittävät niiden painon yhteisessä päätöksenteossa. Matalan inflaation maat saavat päätöksenteossa suhteessa muita suuremman painon. Suhteellisen suuri paino tulee myös maille, jotka panevat muita vähemmän painoa saamilleen tai maksamilleen kansainvälisille tulonsiirroille.

Asiasanat: Inflaatioteoria, rahaliitto, rahapolitiikka

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# 1 Introduction

The development of the positive theory of inflation since the seminal contribution of Barro and Gordon (1983) has constituted a great breakthrough in the economics of monetary policy. The result has been a much deeper understanding of the problems inherent in discretionary monetary policy, such as the tradeoff between flexibility and credibility in different macroeconomic and institutional set-ups.

The literature has mainly concentrated in the analysis of single-country problems, however. This is a significant shortcoming, especially in view of the ongoing efforts to form a federal monetary union in Europe, arguably the most outstanding monetary policy enterprise of our time. Among the notable exceptions to the general shortage of literature in the field of positive theory of federal monetary policy are the contributions of Alesina and Grilli (1992), and von Hagen (1995). Both of these studies discuss the determination of monetary policy in federal monetary unions, emphasizing the role of political processes and political commitments. Voting behaviour of citizens or monetary policy decision makers is the focal point in this strand of work.

The present study contributes to the positive theory of federal monetary policy with another approach. The difference is in the decision mechanisms assumed to be used in the decision making body of the common monetary agency of the union – the council of the ECB, say. We assume that to ensure continuity, federal monetary policy makers in fact develop a practice of consensus in their decision making. The aim of the paper is to analyse the prerequisites for such a consensus, as well as its consequences in terms of the policies followed.

We start from the simple, deterministic multicountry model of common monetary policy proposed in Tarkka and Åkerholm (1993) and develop it to take stochastic supply shocks into account. The monetary policy consensus in the model rests on an intercountry transfer mechanism, resembling a scheme designed to redistribute tax or seigniorage revenues. It turns out to be possible to characterize the transfer mechanism which will unify the monetary policy preferences of the representatives of the participating countries, even when the countries face asymmetric shocks. The resulting monetary policy is also characterized.

The main message of the paper is that, if consensus mechanisms are used (at least de facto) in the formulation of federal monetary policy, this will lead to an inflation bias which is a kind of average of the stand-alone inflation biases of the participating countries. Low-inflation countries will probably have a larger weight in this "monetary policy aggregation" than those with a high inflation bias, however.

Another observation is that the common monetary policy will react to the supply shocks faced by the participating economies, but this kind of activism will be rather limited if the shock are idiosyncratic and if the number of countries participating is large. The reaction of the common monetary policy to an idiosyncratic shock in a member country will depend crucially on the economic characteristics of the country as well as on its preferences regarding inflation, employment and external transfers. The transfer system will react to both symmetric and asymmetric shocks in such a way that the intrinsically high-inflation countries refrain from advocating monetary accommodation of shocks.

## 2 Positive and normative inflation theory

In this section, we discuss some aspects of the Rogoff (1985) model of monetary policy which will constitute the single-country starting point of the analysis of common monetary policy in federal monetary unions.

The Rogoff model is based on the dynamic consistency problem which arises when the central bank has the option to reconsider its monetary policy after nominal decisions (regarding wage contracts, for example) have been made on the basis of inflationary expectations. In this situation, the central bank will have a temptation to induce a surprise inflation if output is sensitive to the real wage level and if the central bank prefers higher than the natural rate of output.

The positive theory of inflation is based on the "discretionary" solution of the model, meaning that the central bank yields to the temptation to inflate; the solution also supposes rational expectations on the part of the general public, meaning that the central bank's policy is correctly anticipated by the inflationary expectations in the first place. Therefore, the equilibrium involves inflation without any economic benefit from it on average; on the other hand, an unexpected decision not to inflate would create a recession.

An attractive feature of the Rogoff model is that it allows for the analysis of the interaction of monetary policy decisions with supply side disturbances. The issue becomes relevant if one assumes that the central bank can observe the disturbances before it decides upon its monetary policy, but the shock is unobservable by the general public when it determines its inflationary expectations. It can be shown that a short-term tradeoff between price stability and real stability emerges, so that the higher is the priority set on real stabilization, the higher will be the inflationary bias induced in the economy. The choice will depend on the central banker's preference function.

This basic model has been developed later in several ways. The most notable developments have taken the model to a normative direction, seeking institutional arrangements which would, to the highest degree possible, avoid the time inconsistency problem and the resulting inflationary bias in the economy.

In one of the normative extensions, Rogoff analysed the optimal choice of the central banker by the general public (in terms of the preferences of the banker as an agent), arguing that the central banker should optimally be more conservative towards inflation than the society as a whole. The solution is only second best, however, since inflationary bias is not fully eliminated.

Later, Walsh (1995) has argued that even better solution may be devised: a suitable remuneration schedule written for the central banker will result in a socially optimal policy. The optimal schedule punishes the central bank if it inflates the economy in a socially suboptimal way. The problem in the Walsh solution is, however, that the remuneration schedule may perhaps be renegotiated after inflationary expectations have been set. This possibility destroys the credibility of the prescribed remuneration schedule and, hence, the credibility of monetary policy as well (al-Nowaihi and Levine, 1996).

In what follows, we take the strictly positive approach. The aim of the paper is thus not to look for optimal institutional arrangements, but instead to predict what would happen under some not obviously unplausible conditions.

### 3 The model of common monetary policy

According to Borch (1984), in group decision making situations, there always exists a prescribed compensation scheme (a sharing rule) which creates unanimity about ordering of alternatives. In the context analyzed by Borch, this rule is also Pareto optimal. Below, we apply this result to monetary policy decisions in a monetary union. This is motivated by the observation that consensus may yield some benefits as such in monetary policy, because frequent disagreement in the decision making body could risk continuity and credibility of any chosen policy. For example, the German Bundesbank has often mentioned the general support of the population of the country as one of the preconditions of successful monetary policy. When unanimity has some value, mechanisms tend to evolve which serve to create and maintain this unanimity; much of the development of institutions and standing contractual arrangements can be interpreted as evidence of this. In what follows, we simply assume that there is a system of international, monetary policy dependent transfers and ask the question what kind of system will create unanimity on monetary policy and what kind of policy will be chosen as a result of this unanimity.

#### 3.1 The stand-alone solution

The model consists of a number of countries with possibly different economic structures. Each country has a supply function of the following, usual Lucasian type relating the output performance of the country to unexpected inflation and supply disturbances.

$$y_i = \bar{y}_i - b_i + \alpha_i(\pi_i - \pi_i^e) + \mu_i \quad (1)$$

The symbols are conventional in the literature. The subscript  $i$  refers to the name of the country in question.  $b_i$  denotes the natural rate of unemployment (capacity underutilisation) due to tax distortions or labour market imperfections. The last term of the equation  $\mu_i$  describes an idiosyncratic supply shock with a zero mean.

Each country has a central banker with the following Rogoff-Walsh loss function:

$$L_i = (y_i - \bar{y}_i)^2 + \beta_i \pi_i^2 + 2\gamma_i T_i \quad (2)$$

The loss function describes the policy preferences of the central banker regarding output, inflation, and external transfers  $T$ . The latter are defined as transfers collected from the country  $i$  and distributed to other countries. In the next subsection, an international compensation and penalty scheme based on these transfers is specified and analyzed.

The higher is parameter  $\beta_i$ , the more conservative is the central banker of the country  $i$  with respect to inflation. The coefficient  $\gamma_i$  measures the valuation of

external transfers in the decision-making. Substituting the supply function into the loss function gives

$$L_i = [\alpha_i(\pi_i - \pi_i^e) + \mu_i - b_i]^2 + \beta_i \pi_i^2 + 2\gamma_i T_i \quad (3)$$

The minimization of (3) with respect to the rate of inflation will constitute the description of the discretionary monetary policy decision making of the central banker  $i$ . Note that, in accordance with the Rogoff procedure, this optimization is done while taking inflationary expectations as given. For simplicity, the central bank is assumed to have complete control of inflation.

Transfers to the rest of the world (outside of the monetary union) play no role in the model, so summing across countries obeys the definition:

$$\sum_i T_i = 0 \quad (4)$$

Now, turn to the actual solution of the model. As a benchmark, it is useful to start by solving for the "stand-alone" monetary policy, meaning the policy which would prevail in the absence of a monetary union and in the absence of external transfers. This assumption means that the stand-alone rate of inflation must be solved for each country separately, under the assumption

$$T_i = 0 \quad (5)$$

The first-order condition for the stand-alone rate of inflation is as follows, observing however (5):

$$\frac{\partial L_i}{\partial \pi_i} = 0 \quad (6)$$

This implies the condition:

$$\pi_i^s = \frac{\alpha_i^2}{\alpha_i^2 + \beta_i} \pi_i^e + \frac{\alpha_i}{\alpha_i^2 + \beta_i} (b_i - \mu_i) \quad (7)$$

Where  $\pi^s$  denotes the stand-alone rate of inflation. Now, taking expectations throughout (7) we get the rational expectation of the stand-alone rate of inflation, which is of course also the actual inflationary bias in the country  $i$  in the absence of a monetary union:

$$\pi_i^e = \frac{\alpha_i b_i}{\beta_i} \quad (8)$$

This is a standard result, giving the inflationary bias as a function of the slope of the supply function of the economy  $\alpha_i$ , the natural rate of unemployment  $b_i$ , and the degree of conservativeness of the central bank  $\beta_i$ . The inflationary bias is low if the output does not react much to inflationary surprises, if the natural rate of unemployment is low and if the central bank is relatively conservative.

Substituting (8) into (7) and simplifying yields the following characterization for the stand-alone monetary policy denoted by the inflation rate  $\pi_i^s$  for country  $i$ .

$$\pi_i^s = \pi_i^e - \frac{\alpha_i}{\alpha_i^2 + \beta_i} \mu_i \quad (9)$$

Inflationary surprises will occur, according to the model, as a result of negative supply disturbances. Using the supply function once more allows one to solve for the output under stand-alone monetary policy:

$$y_i^s = \bar{y}_i - b_i + \frac{\beta_i}{\alpha_i^2 + \beta_i} \mu_i \quad (10)$$

It is seen from (10) that the stand-alone monetary policy reacts to the supply disturbance with a degree of accommodation which depends positively on the degree of conservativeness of the central bank and negatively on the slope of the supply function. In the event of a positive supply shock, say, the central bank will engineer a surprise deflation which will neutralise part of the shock, but part of it will nevertheless be reflected in the actual output, depending on the accommodation coefficient in (10).

### 3.2 The union solution

Now we turn to analyse the determination of monetary policy in a federal monetary union. We start by considering the preferred inflation rates of the central banker  $i$  when the external transfer system is in place. Differentiating (3) in full gives the following first-order condition for the inflation rate preferred by the country  $i$ :

$$\frac{\partial L_i}{\partial \pi_i} = 2\alpha_i^2(\pi_i - \pi_i^e) - 2\alpha_i(b_i - \mu_i) + 2\beta_i\pi_i + 2\gamma_i \frac{\partial T_i}{\partial \pi_i} = 0 \quad (11)$$

It is convenient to express (11) with the help of the stand-alone rate of inflation defined above. It is seen that the preferred rate in the union case deviates from the stand-alone rate by an amount which depends on the characteristics of the transfer mechanism:

$$\pi_i^* = \pi_i^s - \frac{\gamma_i}{\alpha_i^2 + \beta_i} \frac{\partial T_i}{\partial \pi_i} \quad (12)$$

Now, in a monetary union there is only one monetary policy which in the present model construction means a single inflation rate. This common monetary policy is assumed to be jointly determined by the central bankers from all of the member countries. They may form the council of the federal central bank, for example, as is prescribed in the Maastricht Treaty.

We wish to characterize the conditions under which the central bankers convening to determine the common monetary policy might agree on their single decision parameter. Mathematically, the unanimity is defined as follows:

$$\pi_i^* = \pi^u \quad (13)$$

Now, the condition for country  $i$  to actually agree with the rest on the formulation of monetary policy can be derived by substituting (13) into (12):

$$\frac{\partial T_i}{\partial \pi_i} = \frac{(\alpha_i^2 + \beta_i)}{\gamma_i} (\pi_i^s - \pi^u) \quad (14)$$

The interpretation of (14) is that the consensus on monetary policy can be achieved under suitable transfer mechanisms. The critical thing is the sensitivity of the external transfers to the rate of inflation, as measured by the partial derivative in (14).

It is seen from (14) that, to support unanimity, the transfer to abroad should be an increasing function of the inflation rate (or activity) for those countries whose stand-alone inflation rate would be higher than the common (union) rate of inflation. Conversely, the countries with a stand-alone rate which is lower than the common inflation rate should receive marginal subsidies related to activity or inflation. Naturally, these tax of subsidy rates are inversely proportional to the weight of the transfers in the central banker's preference function.

The next step is to determine the common rate of inflation. To do this, note first that the marginal transfer rates must by definition sum to zero:

$$\sum_i \frac{\partial T_i}{\partial \pi_i} = 0 \quad (15)$$

Sum now the unanimity condition (14) over  $i$  and apply (15); this yields

$$\sum_i \frac{(\alpha_i^2 + \beta_i)}{\gamma_i} \pi_i^s = \pi^u \sum_i \frac{(\alpha_i^2 + \beta_i)}{\gamma_i} \quad (16)$$

which may be written in the "weighted average" form, giving the common inflation rate as a linear combination of the national stand-alone inflation rates:

$$\pi^u = \sum_i \omega_i \pi_i^s \quad (17)$$

Here, by (17), the weights are as follows:

$$\omega_i = \frac{(\alpha_i^2 + \beta_i)/\gamma_i}{\sum_j (\alpha_j^2 + \beta_j)/\gamma_j} \quad (18)$$

It is seen that the weight of a country in the determination of the common monetary policy (with a transfer-based consensus procedure) depends positively on its degree of conservativeness of the country's representative in the decision-making body; positively on the response of the country's output to a surprise inflation, and negatively on the weight the country attaches to international transfers in its decision-making. Note also that the output sensitivity parameter could well be taken to be positively correlated with the size of the country, if larger countries also add more output (in absolute terms) than smaller ones when stimulated with monetary policy.

The weighted average in (17) is linear. Due to this linearity, the same weighted average formulation is applicable also to the determination of the average inflationary bias in the union on the basis of the stand-alone biases (8).

Regarding the reaction of monetary policy to idiosyncratic shocks, we get from (17) and (9) the following result:

$$\pi^u = \pi^{u,e} - \sum_i \omega_i \frac{\alpha_i}{\alpha_i^2 + \beta_i} \mu_i \quad (19)$$

or, simplifying a bit,

$$\pi^* = \pi^{*e} = \sum_i \frac{\alpha_i/\gamma_i}{\sum_j (\alpha_j^2 + \beta_j)/\gamma_j} \mu_i \quad (20)$$

The results (19) and (20) mean that the common monetary policy will react to the average supply shocks in the area in the same way as a single country would react to its own idiosyncratic shocks. The "average supply shock" is again assessed with the same, size- and preference-based weights which were discussed above. Thus, the reaction of common monetary policy to an idiosyncratic shock in a single country will be limited by the size of the country's weight in the averaging procedure created by the unanimity requirement together with the related external transfer system.

## 4 The transfer system

We now turn to a more detailed discussion of the transfer system required to support the common monetary policy. The condition (14) for unanimity in monetary policy decisions relates the international transfers within the monetary union to actual inflation. Clearly, this does not preclude the transfers from being based on outputs of the participating countries, since it is precisely the short run effect on output which causes the incentives to inflate. In practice, an activity-based transfer scheme could emerge in a variety of alternative forms. The easiest case to analyse analytically seems to be a system of linear, value added-based taxes and subsidies, operating as if the countries would redistribute some part of their VAT revenues among themselves.

In any output-based linear revenue redistribution scheme, in which transfers between two members are independent of the outputs of the rest of the countries, the marginal transfer rates can be characterized by a matrix  $T$  consisting of elements  $t_{ij}$ . The elements indicate the sensitivity of (net) transfers from country  $i$  to country  $j$  with respect to variation in the output of country  $j$ , so that

$$\frac{\partial T_i}{\partial y_j} = t_{ij} \quad (21)$$

The overall budget constraint (4) of the transfer system implies the following condition, meaning simply that the marginal "tax" on a country's output is exactly used up in subsidies to other countries:

$$\sum_i t_{ij} = 0 \quad (22)$$

Note that  $t_{jj}$  is the total marginal international tax rate on country  $j$ 's output. On the basis of the condition (14) for unanimity and the supply functions of the countries, we know that the transfer system must have the following property:

$$\frac{\partial T_i}{\partial \pi_i} = \sum_j t_{ij} \alpha_j = \frac{(\alpha_i^2 + \beta_i)}{\gamma_i} (\pi_i^s - \pi^u) \quad (23)$$

The functioning of the transfer system can be illuminated by the following example.

Consider two countries, one (country A) having a higher stand-alone rate of inflation than the other one (a low-inflation country B). Then the transfer system in a monetary union consisting of the two countries must be such that if the common inflation rate accelerated, country A would end up paying more to country B. This is precisely the feature which keeps the union together in the model.

Assume that the transfer system is specified in terms of output-related taxes and subsidies, as described above. Assume further that the countries face a symmetric, negative shock. This induces some inflation, as monetary policy in the union is relaxed as a response to the shock. Without the effect from the transfer



mechanism, country A would like to inflate more than country B. Since the output shock is only partly offset by monetary policy, the transfer system will, in response to the shock, distribute more income to the high-inflation country A from the low inflation country B. Country A is thus in a way compensated for part of its output loss, and the low-inflation country B serves as the source of these compensating transfers. Of course, in the case of a positive shock, the system must operate in the opposite direction.

## 5 Discussion

We have analysed the prerequisites for a consensus on monetary policy in federal monetary unions, as well as the consequences of such a policy determination procedure.

We have shown that the transfer system capable of supporting consensus on monetary policy can be based on activity-related, automatic subsidies for countries which would individually prefer lower inflation rates, and activity-related taxes for countries which would prefer higher inflation in absence of the transfer system. This kind of transfers decrease the temptation to inflate for the less conservative countries, and increase the payoffs of surprise inflations to the countries otherwise favouring relatively low inflation. Thus, the policy preferences among the union members converge as a result.

It turns out that the common monetary policy created by unanimous decisions under the supporting transfer mechanism can be characterized as a weighted average of the national "stand-alone" inflation rates, i.e. the rates which would prevail without the monetary union. The weights of the countries are not related to the sizes of the national economies, but rather to the national attitudes towards inflation and transfer income. Countries with a low stand-alone rate of inflation get a large weight in the determination of the common monetary policy, as do the countries which have a relatively low marginal valuation of international transfer income.

The results do not seem to be particularly flattering for such a decision-making system. By the very definition of a monetary union, the common monetary policy would thus be relatively insensitive to independent, idiosyncratic shocks in any of the individual countries - much more so than in the stand-alone situation. This is easily seen by considering the case in which the union is assembled out of several, essentially similar countries with however independent supply shocks. The averaging procedure which the consensus mechanism implicitly employs, aggregates away any idiosyncratic supply shocks in such a context.

However, the transfer mechanism required by the monetary policy consensus will at least partly compensate for the variation of output for countries with a high stand-alone rate of inflation (higher than the common rate selected by the union). For these countries, the marginal tax rate is positive, and therefore some stabilization occurs through the transfer system. This result is of course inverted in the case of the low inflation countries.

The stabilization problem could be contrasted with the other result, according to which the inflationary bias in the monetary union would turn out to be some kind of an average of the national stand-alone biases. This does not vanish in

averaging the way idiosyncratic disturbances do, so if consensus is required, the union could have an inflationary bias of the same order of magnitude as in the individual countries before the union.

All this holds, of course, only if the common monetary authority makes policy on a discretionary basis; if the consensus practice is in fact employed as a decision-making procedure; and if it is an explicit (or implicit) intercountry transfer system which in fact is developed and used in order to support the monetary policy consensus.

The realism of the consensus solution could be questioned, of course, but in the absence of more sophisticated institutional arrangements or reputation-building devices it actually seems a possible outcome when a federal monetary union is created. The majority voting solutions have, namely, their own particular problems which may make them unattractive. The possibility of multiple solutions and the resulting instability is one of them.

The central message of the analysis in the paper for the concrete issue of building a monetary union in Europe could thus be that the problems inherent in discretionary monetary policy making seem to be aggravated in monetary unions as compared with the stand-alone case, since at least part of the flexibility to react to shocks is lost anyway, but the inflationary biases do not go away, at least not in the presently considered decision making mechanism. Institutional solutions should therefore be sought to improve upon the consensus/discretionarity combination. The case for credibility-supporting arrangements such as central bank independence is much stronger in a federal monetary union than in each of its member countries taken separately.

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