A Case Study of US Monetary Policy: Reserve Requirements and Inflationary Gold Flows in the Middle 30's

Dr. Karl Brunner *, Los Angeles-Zürich

I. Introduction

1. The rationale of reserve requirements is a moot point of monetary analysis. The historical genesis of the institution (i. e. the concern with the banks' liquidity) provides no logical justification for its existence. Reserve requirements are neither necessary nor a sufficient condition for the existence of an upper boundary to the money-supply [1]. Other justifications refer to the "degree of control" over the money-supply or over the relative change in the money-supply exerted by the monetary authorities. But the existing literature is obscure and undeveloped on this point. A clear recognition and formulation of the problem barely exists. Rationalisations of reserve requirements based on the notion of a "degree of control" over the money-supply are essentially concerned with properties, particularly the variance of the (conditional) probability distribution of the money-supply (or its relative rate of change) [2].

2. We find in the literature on monetary policy still another reason for the existence of reserve requirements and for the discretionary power enjoyed by the Board of Governors. It has been argued that the possibility of gold inflows which are large relative to the Federal Reserve's open market portfolio establishes a sufficient reason for the existence of reserve requirements and for the power to adjust their height. The existence of reserve requirements and the power to change

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[1] A demonstration of the two points will be presented in a paper on "The Rationale of Reserve Requirements".

[2] The paper mentioned in footnote 1 formally develops this notion of "degree of control" and clarifies the relevance of the institution of reserve requirements in this context. The probability-distribution is conditional with respect to policy variables.

their level is considered a necessary instrument to control inflationary impulses generated by the balance of payments. This problem arose in a specific historical situation: The reserve requirements were doubled in 1936 and 1937 by three successive decisions by the Board of Governors [1]. The reason for this deflationary action was the large amount of excess reserves which had accumulated as a result of substantial gold inflows. Goldenweiser insists that "the action of raising reserve requirements seems at this date (1949) to have been the correct policy" [2]. He also describes the general aspect of the specific situation existing in 1936/7 with the following words: "... member banks should not be in a position to expand their operations substantially without being obliged to resort to the Federal Reserve Banks for accommodation [3]." The American Bankers Association stated recently a similar view: "During 1934–41 our monetary gold stock increased by $ 19 billion. This gave rise to a threat of runaway credit expansion, since the Reserve Banks' securities portfolios were too small to enable them to absorb the large excesses reserves by open market sales. Authority to increase reserve requirements became essential to restore a satisfactory degree of control to the system [4]."

II. The Conception of the Federal Reserve-Authorities

1. It would be meaningless to criticize the Federal Reserve's decision taken in 1936/7 on the basis of subsequent observations. Our concern is not directed toward the decision as such, but to its underlying justification. The general form of the reasoning which supported the decision occupies the center of our interest.

[1]

Effective date of change	Central-reserve city-banks	Reserve city-banks	Country-banks
	on net demand deposit		
before 8/1/1936	13%	10%	7%
8/1/1936	19½%	15%	10½%
3/1/1937	22¾%	17½%	12¼%
5/1/1937	26%	20%	14%

From 8/1/36 to 5/1/37 the reserve requirements on time deposits were raised from a level of 3% in the same proportion as the reserve requirements on net demand deposits.

[2] Goldenweiser, *Monetary Management*, McGraw-Hill Book Co., New York 1949, p. 58.

[3] Goldenweiser, *American Monetary Policy*, McGraw-Hill Book Co., New York 1951, p. 175 and 176.

[4] Economic Policy Commission, American Bankers Association: *Member Bank Reserve Requirements*, New York, 1957.

It should be noted incidentally that no concern is expressed about the behavior of the money-supply in the text quoted. The concern stated refers to "credit". This characterizes not only the ABA report but actually most discussions on monetary policy. Also, it is rarely clear whether credit is a *stock* quantity, measured by the existing loan-portfolio of banks, or a *flow* quantity, measured by the time rate of change of the banks loan-portfolio. The concern for the behavior of "credit", so dominant in policy discussions, expresses one or the other of the two hypotheses.

i) "credit" and money-supply (or rate of change of money-supply) are highly correlated.

ii) "credit" is a more relevant quantity than money-supply when we have to account for the behavior of aggregate demand. No evidence has been submitted by anybody who emphasizes "credit" as against the money-supply to substantiate either hypothesis.

This form of reasoning as continuously practised in discussions of monetary policy[1] is the subject of our analysis. The quantitative information extracted from observations of monetary data, while they contribute to our knowledge of the existence and nature of relevant relations, are presented in this context to measure the appropriateness of a prevelant type of policy-reasoning.

2. The following description of the Federal Reserve Authorities' conception is based on the Annual Reports and the Monthly Federal Reserve Bulletin for the years 1935, 1936 and 1937. The Federal Authorities emphasized repeatedly that "the section of the law which authorizes the Board to change reserve requirements states that this power may be exercised in order to *prevent* injurious credit expansion or contraction" [2]. Consequently, action may be taken not only to curb an existing inflationary or deflationary momentum, but also to restrict specific future developments. The law does not state whether the "injurious" credit movements of the future should be expected to occur with considerable probability on the basis of available evidence or just be considered a possibility among other possible outcomes. The Federal Reserve Authorities' interpretation is quite explicit. Their public statements which justify their moves and emphasize the need for caution point to the *possibility* of an injurious credit movement permitted by the large volume of excess reserves. Thus, we find among similar statements: "The Boards action (in 1937) was in the nature of a precautionary measure to prevent an uncontrollable expansion of credit in the future [3]." But this precautionary move was not made in the expectation of an actual or probable "inflationary" danger. In early 1936 the Board explicitly asserted that there is "at present no evidence of overexpansion of business" [4]. In early 1937 the Board explains that "while there was no evidence of excessive expansion in bank loans, the excessive reserves provided the basis for such an expansion and it was considered far better to sterilize a part of the superfluous reserves while they were still unused than to permit a credit expansion to be erected upon them and then to withdraw the foundation of the structure" [5]. At another occasion the Federal Reserve declared that the raise in reserve requirements eliminated the basis of a *potential* credit expansion arising from the gold inflow, or that the excess reserves *might* result in an injurious credit expansion [6]. It was also pointed out that excess reserves remaining after the raise in requirements were such that "reductions or expansions of member bank reserves may be effected through open-market operations" [7]. Thus, the crucial magnitude of excess reserves was considered to be

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[1] e. g. in Goldenweiser's above mentioned books when he asserts 13 years ex post facto that the Federal Reserve's action in 1936/7 has been correct.

[2] 23rd Annual Report of the Board of Governors of the Federal Reserve System, p. 14.

[3] 24th Annual Report, p. 2.

[4] 22nd Annual Report, p. 2/3.

[5] 23rd Annual Report, p. 14. The Federal Reserve authorities also explicitly acknowledged in their 22nd Annual Report for the year 1935, published half a year before their first action, that the country is still short of full recovery and that the "primary objective of the system is still to lend its efforts to a furtherance of the recovery", p. 2/3.

[6] 23rd Annual Report, p. 1/2 and p. 14.

[7] 23rd Annual Report, p. 15.

measured by the difference between the existing volume of excess reserves and the Federal Reserves open-market portfolio. This positive difference had to be wiped ou as it represented, according to Federal Reserve notions, the basis for a possible, uncontrollable "credit" expansion. The rationale for the elimination of the crucial magnitude of excess reserves was thus not a probability-statement, derived from systematic analysis but simply the acknowledgement of a possibility that the excess reserves generated by the gold inflow *could* induce an "injurious credit expansion" [1].

Discussions on inflation or deflation tend to be dangerously meaningless without specifications concerning the orders of magnitude of the processes under consideration. The Federal Reserve fortunately did provide some indications as to the order of this "injurious credit expansion". The Annual Report for 1936 asserted that "Excess reserves held by member banks in June 1936 were sufficient to provide the basis for almost doubling the existing volume of deposits" [2]. One year later we read: "It was estimated that the existing reserves, if utilized as fully as they had been in the past, were sufficient to constitute the basis for an expansion of deposits and currency of more than 30 billion dollars... and if requirements were increased by an additional $33^1/_3$%, the banking system would still have the basis of a potential expansion of more than 5 billion dollars... The excess reserves of about 1 ½ billion dollars which would be eliminated by a further increase of $33^1/_3$% in requirements could, therefore, support an increase in bank deposits which, if it occurred, would unquestionably constitute a credit expansion on a scale injurious to the nation's economy [3]." *Goldenweiser* observed 14 years later that "if fully utilized, this (volume of excess reserves) could support a credit expansion of over 35 billion dollars, on the basis of the requirements then in effect" [4]. And the Federal Reserve Bulletin asserts: "The portion of existing excess reserves which will be absorbed by the Board's action, if permitted to become the basis of a tenfold or even larger expansion of bank credit, would create an injurious credit expansion." "On the basis of 3 ½ billion dollars of excess reserves the increase in deposits at the old ratio could have been as much as 42 billion dollars... [5]."

Two points should be noted about the Federal Reserve's statements on relevant orders of magnitude. First, this quantitative information is again presented in the form of a possibility-statement. The sentences quoted above and the reasoning supporting them [6], can only tell us what the *upper boundary* of the admissible expansion is. But we do not learn whether this upper boundary is approxi-

[1] It should again be noted that the Federal Reserve is concerned with "credit" and not with the money-supply.

[2] 23rd Annual Report, p. 10.

[3] 24 Annual Report, p. 4.

[4] *American Monetary Policy*, McGraw-Hill Book Co., 1951, p. 175/6.

[5] Federal Reserve Bulletin, August 1936, p. 614 and p. 616.

[6] The reasoning is essentially of this form: let r be the average reserve requirements against demand deposits and e the excess reserves then the ratio e/r defines the upper boundary of the deposit-expansion permitted by e.

mately to be expected with any relevant probability or whether reasonable expectation would give us a significantly lower figure. And secondly, no estimate as to the maximum permissible "non-injurious" expansion is made. The Federal Reserve Authorities acknowledged that full recovery was not restored in 1936. Unemployment still measured at least 10% of the labor force. Thus, monetary expansion up to some degree was actually necessary to restore "full employment". We note that the two most important orders of magnitude for a rational policy-decision about reserve requirements were completely ignored by the monetary authorities: the two magnitudes are the degree of expansion reasonably to be expected from a given change in the reserve basis on the one side and the maximum admissible (i. e. full employment restoring) expansion on the other.

3. Basically, the Federal Reserve only stated that among the credit-expansions which were possible on the basis of the given volume of excess-reserves there existed some with a "dangerously large size". This statement was complemented in the Federal Reserve's policy-justification by a hypothesis concerning the position of excess-reserves in the money-supply mechanism and a conception of a monetary strategy to generate full recovery. The Federal Reserve Authorities considered excess reserves to be a pure liquidity-trap, a quantity without any function in the mechanism which determines the money supply. Thus we read: "The part of excess reserves eliminated was superfluous for prospective needs..." or "... it was considered far better to sterilize a part of the superfluous reserves..." The following statement implies the same idea: "In raising reserve requirements it was not the intention of the Board to reverse the policy of monetary ease [1]." In order to understand this idea concerning excess reserves precisely and to prepare the way for a translation into an empirical hypothesis which can be subjected to tests it is useful to specify it as a property of the banks' loan-supply function [2]. The pure surplus idea of excess reserves indicates that the position of the loan-supply curve, in terms of income and loan-conditions (price) is independant of the

[1] 23rd Annual Report, p. 14/15. On p. 213 of the 22nd Annual Report the Federal Reserve complains that "present excess reserves continue to be excessive". Also, Goldenweiser repeats 14 years later the same argument: "An increase in requirements would diminish the area of independent expansion of member banks without infringing on their existing position."

[2] The loan-supply function can be written in the following form:

$$l^s = l^s(c, Y, Y^0, e, i)$$

where c = loan-condition vector, l^s = loan-supply, Y = current GNP, Y^0 = last highest GNP, e = excess reserves, i = yield on fixed interest bearing paper. This equation is a component of a fully formalized money-supply theory. The Federal Reserve's idea can then be expressed by one of the two properties:

i) the derivative of l^s with respect to e is zero,

ii) there exists some $e_0 > 0$ so that for all $e > e_0$, the derivative of l^s with respect to e vanishes.

The two properties are not the same. But the Federal Reserve pronouncements are too vague to distinguish what they actually mean. The first interpretation contradicts the Federal Reserve's own assertions as to the effectiveness of monetary policy and on the function of excess reserves in the mechanism transmitting monetary policy actions to the money-supply and the capital market. No such difficulty exists for the second interpretation. It should be added: no proper investigation of the problem exists and no evidence has been presented so far.

volume of excess reserves. In such circumstances an increase in the money-supply can only occur as a result of a rise in loan-demand, brought forth by higher income. There is no contribution from the loan supply factors to raise the money-supply according to this scheme.

The strategy conception of monetary policy is described by the following sentences: "The present volume of deposits, if utilized at a rate of turnover comparable to pre-depression levels, is sufficient to sustain a vastly greater rate of business activity than exists today. In order to sustain and expand recovery the country's commerce, industry and agriculture therefore, require a more complete and productive utilization of existing deposits rather than further additions to the amount now available [1]." Thus, the Federal Reserve observes that velocity in 1936 is substantially below the level of 1929, realises that an increase of velocity to the old level would assure full recovery and so concludes that there is no need to increase the money-supply in order to absorb the remaining unemployment, an increase in velocity is really required.

III. The Meaning of Possibility-Statements and the Nature of Meaningful-Statements in Economics

1. We disregard in this paper the justifications of the Federal Reserve's policy in form of the specific excess reserve hypothesis and the "exhortatory" conception of monetary policy. What remains is a strong emphasis on certain possibilities, on some particular outcomes. A persual of the literature on monetary analysis and monetary policy reveals a marked propensity on the part of economists to formulate possibility-statements and also to draw conclusions from such statements. The meaning of these statements is often ambiguous and their logical function mostly vague. This also holds for the steps intervening between possibility-statements and policy-decisions.

The manner in which possibility-statements are used suggest the following three types, acceptable according to modern scientific methodology:

a) Possibility-statements are used to delimit the fundamental probability set (in the sens of *Neyman*). As all social relations are of a stochastic nature, every investigation of social phenomena has to define the class of all possible outcomes of an experiment consistent with our a priori information [2]. The Federal Reserve's sentence declaring the possibility of a credit-expansion to the upper boundary determined by reserve requirements can be conceived in this way: It states the upper boundary point of the fundamental probability set in question. As the lower boundary point is necessarily given by zero, the whole set is consequently clearly specified by the sentence.

[1] Federal Reserve Bulletin, February 1937, p. 96.

[2] A priori information is a priori relative to a forthcoming batch of observation but not relative to any observation. The term "experiment" is used in a general sense consistent with modern statistical theory.

b) In many circumstances possibility-statements are meant to convey more than just a delineation of the fundamental probability set. They are intended to indicate in addition a specific property of the fundamental set, expressed by *Bayes* postulate or the *Laplace* principle of indifference. In modern terminology we may state that possibility-statements are used as a device to stipulate a fundamental set together with a class of approximately rectangular distributions.

c) Possibility-statements are a device to define the class of a priory admissible hypotheses. This class is of fundamental importance in statistical tests of hypotheses. No testing is possible without a precise specification of such a class, which reflects the available a priori information.

The description of the three types of possibility-statements should clearly indicate that such sentences are not empirically empty or useless. Unfortunately, not all possibility-statements actually occurring in monetary analysis fall into one or the other of the above categories. They are too obscure for relevant scientific usage [1]. Possibility-statements of the first and third type may be described as empirical sentences of the lowest order, with the least content. The second type on the other hand contains a definite empirical hypothesis as to the probabilities of the a priori possible outcomes. This hypothesis can often be tested as against alternative hypotheses about the distributions governing the fundamental probability set. The second interpretation plus a set of specific alternative hypotheses forms a specific case of interpretation three.

2. If the theory underlying some conclusions or policy-decisions does not go beyond one or the other of the above three cases, then only the barest information is available. Consequently, we would expect the conclusions to border on the trivial. Even so, as decision theory has demonstrated, rational decision-processes can be formulated. But the value of rational decisions would increase, if significantly more information could be made available by economic research. The basic issue really turns then on the existence of empirical statements in economics with considerably more content than the possibility-statements of the three above-mentioned types. If such statements, particularly in monetary analysis, cannot be established, then the usual policy rationalisation, and specifically the reasoning associated with the raise in reserve requirements in 1936/7 must be accepted – at least in its general outline. But if assertions with more content can be inferred from observations with a high "degree of plausibility", then the widespread policy-arguments in terms of possibility-statements must be considered to be quite unsatisfactory. In fact, they neglect essential information and thus are prone to lead to substantially sub-optional decisions.

The search for meaningful statements with greater content than the scientifically relevant possibility-statements is nothing else than a search for economic

[1] There are many instances where they seem a more or less unconscious psychological device which misleads writer and reader. An array of possibility-statements, particularly when interspersed with liberal usage of "maybe's" creates an impression of empirical meaningfulness. But this meaningfulness is only apparent. They are used to generate an unwarranted feeling of "realism" and to hide the actual absence of empiricial content.

laws. Unfortunately, the tradition of classical physics contributed to shape a concept of economic laws which seriously endangers the search for meaningful and valid sentences. The laws of classical physics enjoy a beautiful simplicity of structure expressed by the twin notions of "determinism" and "constants". A search for similar laws in economics may well be futile. But this does not undermine the existence of economic laws in the sense of meaningful and valid statements.

3. The nature of meaningful statements in economics can be clarified in the following terms: Let x indicate a vector of endogeneous economic variables, y a vector of exogeneous variables, and u a random vector, expressing errors of measurement and the indeterminacy of social patterns. f denotes a vector function which is a member of a class F of such functions, p a probability-distribution of u which is a member of a class P of such distributions. The most general features of an economic theory can be stated as follows

$$f(x, y, u) = 0 \qquad p \varepsilon P \quad f \varepsilon F$$

The two classes P and F determine together a class H of conditional distributions of x with y given. H is the class of a priori admissible hypotheses. So far, a fundamental postulate has been introduced, namely, that "nature" can be understood in terms of stochastic schemes. This postulate is usefully formulated more specifically like this, that there exists a true f and p – conceivably members of F and P which govern the observable joint behavior of x and y. It would be meaningless to discuss the validity of such a postulate by itself, as it is not a meaningful statement. What matters is the opportunity to derive meaningful statements from this postulate, and the usefulness of the postulate depends on relevance and validity of implications obtained.

It follows from the fundamental postulate that there exists a subset H_0 of H which describes the "existing true state of affairs" in so far as x and y are concerned. The aim of scientific inquiry is to specify a subset H_1 of H which contains H_0 and is as small as possible. The smaller H_1 the greater is the empirical content of the associated hypothesis. Also, every scientific hypothesis, characterized by some subset H_1 of H will be valid if H_1 contains H_0. If we call a valid hypothesis a law, we may state that the search for laws with maximal content (i. e. with minimal associated subsets H_1 containing H_0) is the essential purpose of scientific work. For our purpose we distinguish between two broad categories of laws according to the nature of the subset H_1:

1. H_1 contains one element only
   a) with negligible variance,
   b) with significant variance.
2. H_1 contains more than one element.

The laws of classical physics are of the type 1 *a)*. They are essentially deterministic and completely specified by a set of constants (which define f). In economics we may have to be satisfied with 1 *b)* and 2. But systematic efforts to establish such laws would assure us of a substantial advance in economic knowledge. Empirical work of past decades indicates that sufficiently restricted subsets H_1 can be formulated so as to specify orders of magnitude for properties of f and p in the subsets of F and P associated with H_1. These orders of magnitude will determine (stochastic) boundary conditions to the joint behavior of x and y. And an achievable goal of economic research as a rational basis of policy decisions is the derivation of sufficiently narrow boundary conditions.

IV. A Monetary Analysis of the Expansion 1933–1937

A. Outline of the Expansion

1. The decision to raise reserve requirements had been taken in summer 1936 after more than three years of expansion. Tables 1 and 2 summarize a few basic features of the longest expansion process recorded by the National Bureau of Economic Research. At the end of this upswing – in 1937 – the real volume of GNP had been pushed 2.6% above its 1929 level and the real volume of private aggregate demand had just reached its pre-depression level. A similar situation is revealed by the FR index of industrial production. Towards the end of 1936 the volume of industrial production had edged into the neighborhood of pre-depression magnitudes. While these magnitudes had been associated with full employment in 1929, continuous growth of underlying production factors for eight years implied that the 1929 real volume of economic activity was still substantially below capacity-output obtainable under the 1936/7 condition. The figures on unemployment and unemployment percentage—in spite of their margin of error—clearly demonstrate this fact. When the long upswing terminated in the second quarter of 1937, unemployment was still approx. 10% of the total civilian labor force. And in the summer of 1936, when the first decisions "to prevent injurious credit expansions" were taken, the unemployment percentage measured 11% after a winter with 19% of the labor force unemployed. Expressed in current prices, aggregate demand in 1937 was considerably below the 1929 level, indicating that general prices were still below their pre-deflation level. Nevertheless, the rate of increase in prices from the depression low is impressive. The wholesale price index rose from the first quarter of 1933 until the summer of 1937 by roughly 45% and the cost of living index over the same period by approx. 23.6%. The movement of wholesale prices shows three distinct subperiods. From 1/1933 to 1/1935 we observe a pronounced rise by approx. 33% followed during the period 1/1935–2/1936 by a remarkable stability. From 2/1936 until 2/1937 wholesale prices surged up again by approx. 10%. But the rate of increase per quarter in the second surge of the upswing was only 2.5% as against about 4% in the first subperiod. The pattern of motion of the cost of living index is different. From the depression trough in 2/1933 there is a quick jump in the next quarter followed subsequently by gradually smaller rises until towards the end phase of the upswing in late 1936 the upwards motion accelerates again.

Table 1. Production, Prices, and Unemployment. Quarterly averages of monthly data

Quarter		Index of Industrial Production adj. 1923–25 = 100	Index of Wholesale Prices 1926 = 100	Index of Cost of living 1923 = 100	Unemployment in 1000's	Unemployment as a per cent of Labor Force
1932	1	69.33	66.53	80.63	11 549	23.14
	2	60.67	64.60	78.40	10 485	20.95
	3	61.33	65.00	77.00	11 265	22.47
	4	60.00	63.63	75.50	12 243	24.33
1933	1	62.33	60.33	72.57	14 449	28.63
	2	78.33	62.70	72.37	12 130	23.97
	3	91.67	69.73	77.07	10 283	20.27
	4	74.33	71.03	77.73	10 506	20.65
1934	1	81.00	73.17	78.33	11 256	22.06
	2	85.33	73.87	79.00	8 040	15.71
	3	73.33	76.27	79.93	9 180	17.89
	4	78.33	76.63	80.40	10 584	20.57
1935	1	89.33	79.23	81.73	11 249	21.81
	2	86.00	80.03	82.67	8 501	16.45
	3	88.33	80.20	82.50	8 126	15.69
	4	97.33	80.67	83.43	8 489	16.33
1936	1	94.67	80.27	83.53	9 945	19.11
	2	102.00	79.17	84.10	6 959	13.34
	3	108.33	81.23	85.57	5 968	11.42
	4	115.00	82.70	85.87	6 670	12.73
1937	1	116.00	86.67	87.33	8 424	16.04
	2	116.67	87.53	88.67	5 358	10.26
	3	114.00	87.60	89.10	4 750	9.00
	4	91.33	83.47	89.03	7 081	13.39

Note: The Index of Industrial Production is compiled by the Board of Governor of the Federal Reserve System. Wholesale Prices Index is compiled by the US Department of Labor and Cost of Living Index compiled by National Industrial Conference Board. All monthly data of the three variables were taken from the Survey of Current Business Supplement 1936 and 1938. Unemployment and Labor Force Data were obtained from the Economic Almanac, 1956. The last two variables are not seasonally adjusted.

2. Table 2 suggests that the movements of prices and industrial production are related with each other. Closer inspection indicates that periods with more rapidly rising prices are vaguely bunched around periods of more rapidly expanding industrial production. In order to test the existence of a relation between price and production and to evaluate its general quantitative nature, an equation, suggested by *Tinbergen* [1], was formulated for the period 1/1932–4/1937. The first two regressions in table 3 show the result. They are obtained from the

[1] J. Tinbergen, *Economic Policy:* "Principles and Design", North-Holland Publishing Co., Amsterdam, 1956, p. 231, model 02, the price fixation equation.

data in table 1. Both correlations are significant at the 95% level and so are consequently the regression slopes. Of particular interest is the size differential between the slopes for the cost of living index and the wholesale price index. A given industrial expansion was associated in the average over the period under consideration with an increase in wholesale prices nearly double the resulting rise in the cost of living. The reaction-elasticity of prices p relative to production π can be derived from the equations in the form

$$\left| \frac{dp}{d\pi} \frac{\pi}{p} = \frac{a_1 \pi}{a_0 + a_1 \pi} < 1 \right|$$

As $a_0 > 0$ for both equations we observe that the reaction-elasticity is below unity. The derivative of this elasticity is positive and thus it is established that the reaction-elasticity of prices with respect to production rises with production.

Table 2. Aggregate Demand in Current and Constant $ Velocity and Percentage Changes of Money Supply and Aggregate Demand. Value figures in billion of $

Years	1929	1932	1933	1934	1935	1936	1937	1938
A_1 in current dollars	104.4	58.5	56.0	65.0	72.5	82.7	90.8	85.2
A_2 in current dollars	95.2	50.2	47.8	54.8	62.6	71.0	79.0	71.3
A_1 in constant dollars	149.3	107.6	103.7	113.4	127.8	142.5	153.5	145.9
A_2 in constant dollars	134.1	92.2	88.7	95.8	110.9	122.8	134.0	121.9
Velocity 1		2.88	2.92	3.02	2.84	2.83	3.00	
Velocity 2		2.47	2.49	2.55	2.45	2.43	2.61	
Percentage change in M relative to 1933				+ 12.12	+ 33.30	+ 52.22	+ 58.16	
Percentage change in A_1 relative to 1933				+ 16.07	+ 29.53	+ 47.85	+ 62.14	
Ratio of percentage change in M to percentage change in A_1				.75	1.13	1.09	.94	

Note: A_1 = Gross National Product. A_2 = sum of comsumption expenditures and gross private domestic investment expenditures. The constant $ are dollars of 1947 purchasing power. A_1 and A_2 were taken from the National Income Supplement of the Survey of Current Business, US Department of Commerce, 1954. M = money supply (= demand deposits adjusted plus currency outside banks). Per cent changes are derived from annual averages of seasonally adjusted monthly figures obtained from the National Bureau. The definition of velocities is given by the formulae

$$V_i = \frac{A_i}{M} \quad i = 1,2.$$

3. Lines 6–10 of table 2 exhibit some features of the monetary components of aggregate demand. The two measures of velocity are related to two different measures of aggregate demand. Both velocity measures behave during the whole period in essentially the same way: A slight increase from the bottom of the depression and a subsequent decline with an approx. 6%–8% jump in the terminal phases of the upswing. Over the whole period velocity maintains a remarkable (relative) stability. This is clearly indicated by line 10 which shows the ratio of the figures in lines 8 and 9. The data in line 10 can be interpreted as measuring the relative contribution of the money-supply to the expansion in aggregate demand [1]. Two points should be noticed: first, for two years velocity declined so that the money-supply's relative contribution exceeded unity, and second, the relative contribution apparently tended to unity [2].

4. The last two regressions in table 3 lend strong support to the notion of a relation-ship between aggregate demand, money-supply, and prices. The equations follow a form suggested by *Friedman* to introduce a deflator without creating spurious correlation. The reader should note the approximate equality of the price-regression-slopes and the substantial difference of the money-supply regression slopes for the two different measures of aggregate demand. Multiple correlation is high in both cases and barely attributable to chance. But it must be emphasized that the regression established is consistent with two conflicting monetary hypo-

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[1] This can be shown in a simple manner: We start with the standard equation $M.V = A$. From this we derive by logarithmic differentiation

$$m + v = a$$

where $m = \frac{\overset{o}{M}}{M} \cdot 100$, $v = \frac{\overset{o}{V}}{V} \cdot 100$, $a = \frac{\overset{o}{A}}{A} \cdot 100$. Upon dividing through by a we obtain $\frac{m}{a} + \frac{v}{a} = 1$ and $\frac{m}{a}$ is the variable in line 10. $1 - \frac{m}{a}$ measures the contribution of velocity to the expansion.

[2] This observation is consistent with the following interpretation of the quantity-theory: $M.V = A$ and measurement procedures have been specified for M and A. For the case of Switzerland it would be particularly important to specify that M is the money-supply in possession of the *domestic* public. So far, the above equation is only a definition of V in terms of M and A and their peculiar measurement and identification procedure. But now we add a restriction, namely $\left| 1 - \frac{m}{a} \right| \leqq \frac{1}{10}$ where "m" and "a" are defined as in footnote 1, p. 171. But the hypothesis is still not complete. We still have to specify the "realm of application" of the theory. And this field of relevance is circumscribed in two points:

i) whenever m is sufficiently large,

ii) whenever the time-period covered is sufficiently long.

The insertion of boundary values for m in i) and time in ii) forms an essential part of the hypothesis. It should be noted that the two conditions are not completely independent.

Another interpretation of the quantity-theory consistent with the observations would be that $p\left(\left| 1 - \frac{m}{a} \right| \geqq \varepsilon\right)$, where p indicates some probability-distribution, converges towards zero with respect to time and for ε sufficiently small.

Table 3. Relation between Prices and Production, Aggregate Demand, Money Supply and Prices in the 30's

Regressions	Simple Correlations	Partial Correlations	Multiple Correlations
$C = 62.09 + .22\pi$	$.82\,(+.62, +.92)$		
$P_1 = 40.50 + .40\pi$	$.86\,(+.70, +.94)$		
$A_1 = -48.96 +$	$r_{A_1M} = +.82$	$r_{A_1,M.P_2} = +.93\,(+.76, +.98)$	
$1.49\,M +$	$r_{A_1,P_2} = +.81$	$r_{A_1,P_2.M} = +.91\,(+.70, +.97)$	$+.98$
$1.21\,P_2$	$r_{M,P_2} = +.45$	$r_{P_2,M.A_1} = -.78\,(-.37, -.94)$	
$A_2 = -47.43 +$	$r_{A_2,M} = +.76$	$r_{A_2,M.P_2} = +.83\,(+.49, +.95)$	
$.93\,M +$	$r_{A_2,P_2} = +.86$	$r_{A_2,P_2.M} = +.89\,(+.65, +.97)$	$+.95$
$1.20\,P_2$		$r_{M,P_2.A_2} = -.34\,(-.76, +.29)$	

Note: A_1 and A_2 are defined as in table 1. P_2 is an annual wholesale price index with base 1926 = 100 compiled by the US Department of Labor. M is the money supply, measured as an average of June–December figures. P_1 denotes the quarterly average of monthly wholesale price indices in table 2, and C represents column 3 of table 2 and π industrial production, column 1 in table 2. The figures in parentheses in the column on partial correlations state the lower and upper confidence limits of the partial correlation-coefficient at the 95%-level.

theses: a Keynesian-type money or interest residuality hypothesis on the one side and a quantity-theory type hypothesis on the other [1]. If the first hypothesis is valid, then the regression reveals essentially the properties of the demand function for money. If the second hypothesis holds, then the regression reflects properties of a causal mechanism which allocates money-supply a relevant position in the determination of income. It is important to realize that both hypotheses imply the existence of a relation between money-supply and income, strongly confirmed by the regressions. A more detailed econometric analysis is needed in order to evaluate the relative validity of the two alternative monetary hypotheses, and thus to establish, whether the regression reflects mostly demand factors, or also portions of the income-determination mechanism [2]. For our present purposes only the

[1] Specific variants of the two alternative classes of monetary hypotheses clarify the issues:

K-type hypothesis:		*Q-type hypothesis:*
1. $Y = y(Y, p)$		1. $Y = y(Y, r, M, p)$
	2. $M^d = l(Y, r)$	
	3. $M^s = m(B, q)$	
	4. $M^d = M^s = M$	

Y = income, r = interest, M^s = stock-supply of money, M^d = stock demand of money, B = monetary base (to be explained in the subsequent section in the text), q = reserve-requirements, p = a vector of exogeneous factors relevant for income determination (mostly variables relating to government accounts). Equations 2–4 are common to both systems. Eq. 1 has to be understood as a reduced form of a subsystem. A K-type hypothesis is characterized by the assumption that Y can be solved in a subsystem, excluding m and l, in terms of p only, whereas the Q-hypothesis explicitly rejects such assumptions.

[2] Extensive tests have been made to evaluate the relative validity of the two types of hypotheses. Some results were presented at a session of the Swiss Study Group for Theoretical Economics on January 25, 1958, in Zurich. So far all results indicate with surprising unanimity and strenght that the Q-type hypotheses are preferable to the K-type.

existence of a relation between M and A matter. We need not be concerned with the causal interpretation of the relation by means of one or the other of the two hypotheses.

B. The Monetary Situation

a) Outline of Money-Supply Theory

1. The subject matter of monetary analysis can be summarised by three relations and their interactions: the aggregate demand function, the money demand function, and the money-supply function. Aggregate demand and money demand have been repeatedly formalized and estimated. Strangely, the analysis of money-supply has barely reached a stage of a complete formal statement. Textbooks on money and banking offer detailed discussion of fragments of the money-supply mechanism and evaluations of the order of importance of relevant variables. If the material available in such books is sifted and brought together, we obtain suggestions for the construction of a simple money-supply theory. The essential outline of such a theory, needed as a foundation for the subsequent empirical analysis, will be presented in this section. The following 7 equations comprise the basic model:

$$1.\ B = F + A + C - d - o - f - c$$

B = monetary base, F = Federal Reserve Credit, A = gold stock, C = Treasury currency outstanding, d = Treasury deposits at Federal Reserve Banks, o = other Federal Reserve accounts + other deposits at Federal Reserve, f = foreign deposits at Federal Reserve Banks, c = Treasury cash. This is a restatement of the well-known table on "Member Bank Reserves, Federal Reserve Credit and Related Items", regularly published by the Board of Governors of the Federal Reserve System, in form of an equation. It reveals the nature of the mechanism generating the monetary base and the variables which determine the behavior of B. The monetary base can be defined as the total amount of liabilities of the consolidated Treasury-Federal Reserve statement which are money. The importance of B is due to the fact that it forms the basis of the superstructure of deposit-money generated by the commercial banks and is controlled by the monetary authorities.

$$2.\ B = R + C^b + C^p$$

R = reserves of commercial banks at Federal Reserve Banks, C^b = currency held by banks, C^p = currency outside banks (held by the money-using public). This equation describes the allocation of the monetary base.

$$3.\ C^b + R = r(D^p + T)$$

D^p = demand deposits adjusted as a measure of demand deposits held by the domestic public. T = time deposits of commercial banks. 3 formalizes in a simple manner the banks' reserve relation. r is a reserve quotient of the consolidated statement of commercial banks [1].

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[1] A detailed analysis of 5 different measures of the consolidated statements' reserve quotient r has been made. For our purposes in the present paper a measure was chosen which omits on the right side among the deposits all foreign and Treasury deposits. The subsequent analysis in the text is not affected by this choice of r.

$$4.\ r = a_0 + a_1(r^d + e) + a_2 r^t$$

r^d = average reserve-requirements on demand deposits of member banks, e = excess-reserve ratio of member banks, r^t = average reserve requirements on time-deposits of member banks, a_1 and a_2 are indices of relative importance of member banks, measured by the ratio of member banks net demand deposits to total deposits $D^p + T$, and member banks' time deposits to total deposits, a_0 is the ratio of bank held currency to banks' total deposits. Thus, equation 4 partitions the reserve quotient into components which are institutionally significant [1].

$$5.\ C^p = kD^p$$

Equation 5 describes the allocation of the public's money balances as between currency and deposits.

$$6.\ T = tD^p$$

This pictures the allocation of deposits held by the public to demand and time deposits.

$$7.\ M = C^p + D^p$$

The last equation states one of the current definitions of the money-supply. Throughout the paper the concept "money-supply" will be used according to equation 7.

2. The statement of the formal apparatus is the first step in the construction of an empirical hypothesis. The next step is a specification of measurement and identification procedures to be associated with the variables which appear in the formal model. This has already been accomplished: the variables were described in terms which permit their identification with magnitudes measured by the Board of Governors of the Federal Reserve System and published in the statistical tables of the Federal Reserve Bulletin. But such an assignment of observable magnitudes to the variables of the formal apparatus is not sufficient to assure meaningfulness to the above system of seven equations. As a matter of fact, as it stands, even with the one-one correspondence between observable magnitudes and variables established, the system 1–7 has no empirical content. It contains no single meaningful proposition and none could be derived from it. So far, the equations are just definitions of r, k, t, and the components of r. Another step is still required: Restrictions must be formulated in one form or another. Such restrictions in the form of behavior-hypotheses have been formulated for k, t, a_0, a_1, a_2, and e. In addition a

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[1] To be more specific:

$$a_0 = \frac{C^b}{D^p + T},\quad a_1 = \frac{D^m}{D^p + T},\quad a_2 = \frac{T^m}{D^p + T},\quad e = \frac{R^e}{D^m}$$

$r^d = \delta_1 r^{d1} + \delta_2 r^{d2} + \delta_3 r^{d3}$. And where D^m = member banks' net demand deposits, T^m = member banks' time deposits, R^e = volume of excess reserves. r^{d1} = reserve requirements of central reserve city banks, r^{d2} = requirements of reserve city banks, r^{d3} = requirements of country banks. δ_i is the relative weight of the i'th group of banks measured by $\frac{D^{mi}}{D^m}$ where D^{mi} are the net demand deposits of this group of banks.

choice of exogeneous variables has to be made to complete the construction of the theory. We omit for the moment equation 1 and specify B, r^d, and r^t to be exogeneous. The introduction of such restrictions together with the choice of exogeneous variables permits us to interpret now equations 5 and 6 as behavior hypotheses referring to the public, equation 3 a behavior hypothesis relating to banks, and equation 4 a behavior hypothesis concerning the banks reserve quotient. Equation 1 has a special purpose for the scheme. It is used "to go behind" the monetary base B in order to explain the behavior of B. Thus, equation 1 is the formal basis on which we can erect a theory of the magnitude B.

3. From equation 2, 3, 5, 6, and 7 we derive an expression for the money-supply M in terms of the parameters k, t, r, and the monetary base B:

$$8.\ M = \frac{1+k}{r(1+t)+k} \cdot B.$$

It explains the behavior of M in terms of four magnitudes. By using equations 1 and 4 the behavior of B and r can be further decomposed. The function of r, k, and t which multiplies with B to give M is called the "monetary multiplier" and is denoted by "m". As a result of restrictions imposed on k, t, and the components of r equation 8 is not a definition but actually imposes a restriction on the joint variation of M and B. Consequently, we feel justified to call it a money-supply function. This money-supply function forms the framework for the subsequent empirical analysis [1].

b) Analysis of Money-Supply Patterns

1. This section discusses quantitative information about the magnitudes in the money-supply function for the period terminating with the raise in reserve in requirements. Time series of quarterly averages of monthly values of M, B, m, r, k, and t are presented in table 4 from the first quarter of 1932 to the last quarter of 1937. A column is added to the table to describe the behavior of the excess-reserve ratio over this period. At the beginning of the period under consideration the excess-reserve ratio is still very low, below 1%. It jumps upwards in the second quarter 1932 and keeps mounting until the end of 1932. This upward motion of e was broken in the first quarter of 1933, but resumed again in the second quarter of 1933 and maintained until a peak was reached (13.59) in the first quarter of 1936. The first upswing in e in 1932 is associated with a marked increase in k from 27.53 to 30.99. Also, the drop in e from 3.24 to 2.59 comes suggestively after the break in the k's upwards momentum at the end of 1932. The liquidity-crises in early 1933, reflected by k's jump to 35.13 apparently set the stage for a continuous increase in e through the year 1933. In the early months of 1934 the large gold inflow generated by the devaluation of the dollar and the consequent accrual of excess reserves began to dominate e and was the main reason for its upwards motion until 1936.

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[1] A detailed analytical foundation of money-supply theory with a clarification of the logical nature of the relations used will be presented together with an econometric analysis in a subsequent paper on "Monetary Theory and the Money Supply Function". The restrictions to be imposed on k, t, and the components of r will also be discussed in this paper.

Table 4. Quarterly Averages of the Money-Supply and its Determinants

Quarter		Money-supply in million $	Monetary-base in million $	Monetary-multiplier	Reserve ratio in per cent	Currency-deposit ratio in per cent	Time-demand deposit ratio in per cent	Excess-reserve ratio in per cent
1932	1	21 008	7 288	2.883	8.792	27.53	90.08	.31
	2	20 333	7 340	2.772	9.328	28.71	90.59	1.52
	3	19 892	7 642	2.603	10.109	30.99	91.24	1.92
	4	20 094	7 663	2.622	10.597	29.35	88.59	3.24
1933	1	19 601	8 083	2.427	11.115	35.13	86.30	2.24
	2	18 956	7 674	2.470	11.646	33.65	75.73	2.59
	3	18 837	7 685	2.451	12.291	32.03	77.65	3.99
	4	19 254	7 968	2.417	13.304	30.87	75.05	5.37
1934	1	20 266	8 400	2.413	14.324	28.70	72.06	6.75
	2	21 001	8 840	2.376	15.108	27.80	72.01	9.66
	3	21 905	9 267	2.364	15.826	26.74	69.83	10.33
	4	22 763	9 559	2.381	16.346	25.28	67.21	9.57
1935	1	24 095	9 947	2.423	16.533	24.10	64.13	10.94
	2	24 877	10 342	2.405	17.075	23.36	63.56	11.06
	3	26 216	10 810	2.425	17.640	22.13	60.10	11.99
	4	26 983	11 398	2.368	18.531	21.99	59.40	13.52
1936	1	27 410	11 566	2.370	18.420	22.17	59.52	13.59
	2	28 928	11 551	2.505	17.210	21.38	58.05	—
	3	29 893	12 417	2.408	18.601	21.26	56.47	9.92
	4	30 440	13 008	2.340	19.482	21.50	56.16	8.39
1937	1	30 846	13 202	2.336	19.448	21.60	56.55	7.42
	2	30 746	13 270	2.317	19.512	21.84	57.58	4.52
	3	30 334	13 405	2.263	19.738	22.59	60.03	3.43
	4	29 301	13 501	2.170	20.546	23.43	62.79	4.47

Note: All data are quarterly averages of seasonally adjusted monthly figures. The monetary base is the sum of "Money in Circulation" and "total member bank reserve". Money Supply data were obtained from the National Bureau of Economic Research. The Monetary Base was derived from table 101 in "Banking and Monetary Statistics" published by the Board of Governors of the Federal Reserve System, Washington 1943, and then seasonally adjusted. The other variables were computed from deposit and currency series provided by the National Bureau of Economic Research. The excess-reserve ratio is measured by dividing member bank excess reserves by member bank net demand deposits.

The k-variable slid continuously from a maximum of 35.13 to a minimum of 21.26 in the third quarter of 1936. The upturn of k in the last phases of the expansion is also observed in the three expansions of the 20's and the three post WW II expansions. The behavior of t is similar to k's with one marked exception: t rises only very slightly in 1932 and starts a long and rapid decline in the fourth quarter of 1932. A minimum is reached in the fourth quarter of 1936. The reserve quotient starts at a low figure of 8.79%. There follows a continuous rise until the fourth quarter of 1935, a subsequent decline until the second quarter of 1936. The increase in reserve requirements initiates again an upward motion which lasted well beyond the period investigated here.

The monetary multiplier shows the joint effect of the data in the previous columns. A casual look at the figures in the column indicates three clearly distinguishable periods. First, a period of rapid decline from 2.883 to 2.427 started with the first quarter of 1932 and terminated one year later. During this year the monetary multiplier contracted by 15.8 % due to the increase in r and k. The second period lasts from the first quarter of 1933 to the second quarter of 1936. The range of variation of the second period is .141 and as a percentage relative to the average of the extreme values of the range it measures 5.8 %. This interval of relative stability of m is followed by a rapid decline from 2.505 to 2.170. This decline is due to the concurrent action of r, t, and k which operate to move m in this period in the same direction.

The monetary base shows three distinct movements. First, from the first quarter 1932 to the first quarter 1933 there is an increase by approx. 800 million dollars. This combined with the observation of a further decline in the money-supply by approx. 1400 million dollars gave rise to the strongly entrenched legend of the ineffectiveness of monetary policy and particularly of open-market policy. A second period covers the quarters 2–4 of the year 1933 when the monetary base drops below the level reached in the first quarter. And the third period begins with the first quarter of 1934 and lasts to the end of 1937. It is marked by a continuous rise of the monetary base.

The money-supply reveals the joint effect of monetary base and multiplier. The depression trough is reached in the third quarter of 1933. But the decline in M is not continuous. There is a slight recovery in the fourth quarter of 1932, at a time of approximately constant monetary base. The recovery is mainly attributable to a small increase in the monetary multiplier. But the monetary base postponed the recovery of M. From its depression trough M follows the upsurge in B until a peak is reached in the first quarter of 1937 when a new decline sets in. The new deflation is initiated at a time when the rise in B has been substantially slowed down and m starts sliding down as a result of the increase in reserve requirements.

2. While summarizing the conception of the Federal Reserve Board in part II it was noticed that the only quantitative information bearing on the "credit-expansion" permitted by a given reserve-basis was the computation of an upper boundary by means of the reciprocal of the average reserve requirements [1]. This reciprocal was until August 1936 approximately 10, shrank to about $7^1/_3$ in August 1936, still further to approx. $6^1/_3$ on March 1, 1937. A comparison with the monetary multiplier indicates that the actual "degree of expansion" was substantially smaller, significantly less than 50 % of the upper boundary value computed by the reciprocal of reserve-requirements. Even with the highest m observed — 3.917 on June 1929 (due to a very low $k \sim 15$ %) — m was still less than 40 % of the upper

[1] The same procedure still characterises the reports on the reductions in reserve-requirements in February-March 1958.

Table 5. Percentage Changes in Money-Supply, Monetary Base, and Monetary Multiplier

Quarter		Percentage change in money-supply	Percentage change in monetary-base	Percentage change in Multiplier
1933	1	— 6.70	+ 10.91	— 15.82
	2	— 6.77	+ 4.54	— 10.89
	3	— 5.30	+ .56	— 5.84
	4	— 4.10	+ 3.98	— 7.82
1934	1	+ 3.40	+ 3.91	— .58
	2	+ 10.79	+ 15.19	— 3.81
	3	+ 16.29	+ 20.59	— 3.55
	4	+ 18.23	+ 19.97	— 1.49
1935	1	+ 18.89	+ 18.42	+ .41
	2	+ 18.46	+ 17.00	+ 1.22
	3	+ 19.68	+ 16.65	+ 2.58
	4	+ 18.54	+ 19.23	— .55
1936	1	+ 13.76	+ 16.28	— 2.19
	2	+ 16.29	+ 11.68	+ 4.16
	3	+ 14.03	+ 14.87	— .70
	4	+ 12.81	+ 14.13	— 1.18
1937	1	+ 12.53	+ 14.14	— 1.43
	2	+ 6.28	+ 14.88	— 7.50
	3	+ 1.47	+ 7.96	— 6.02
	4	— 3.74	+ 3.79	— 7.27

Note: The formulae for the percentage changes are

$$\frac{M_t - M_{t-4}}{M_{t-4}} \cdot 100, \quad \frac{B_t - B_{t-4}}{B_{t-4}} \cdot 100, \quad \frac{m_t - m_{t-4}}{m_{t-4}} \cdot 100.$$

M = money-supply, B = monetary base, m = monetary multiplier, t = indication of quarter.

The reader may observe that the sum of the percentage changes in the monetary base and the monetary multiplier is not equal to the percentage change in the money-supply. The discrepancy is due to two factors:

i) We compute on the basis of a differential in the neighborhood of a point of a non-linear function.

ii) The averaging introduced rounding errors. Also, to save time, the quarterly percentage changes were computed directly from already available quarterly averages of monthly data instead of averaging the percentage changes of monthly figures.

The discrepancy generated by the factors mentioned does not distort the relative orders of magnitude of the two components of the money-supply's growth rate.

boundary value indicated above for this particular year. The behavior of m over the past decades indicates and the subsequent discussion of a regression table will also emphasize that much better quantitative information concerning the reaction to a given change in B (or in excess-reserves) can be obtained from a systematic analysis of observations [1].

3. A casual inspection of table 4 suggested strongly that until the close of 1933 M's behavior was dominated by behavior patterns originating in the public (as reflected by k) and the banks (as reflected by e and r) and subsequently by the monetary base. The information in table 5, derived from the data in the first three columns of table 4, corroborate the suggestion. Before reading the table the reader

Table 6. Percentage Changes in Money-Supply and Monetary Base relative to 1933

Quarter		Money-supply	Monetary-base
1934	1	+ 5.76	+ 6.98
	2	+ 9.60	+ 12.58
	3	+ 14.31	+ 18.02
	4	+ 18.77	+ 21.74
1935	1	+ 25.75	+ 26.68
	2	+ 29.82	+ 31.71
	3	+ 36.81	+ 37.67
	4	+ 40.81	+ 45.16
1936	1	+ 43.04	+ 47.30
	2	+ 50.96	+ 47.11
	3	+ 56.00	+ 58.14
	4	+ 58.85	+ 65.67
1937	1	+ 60.97	+ 68.14
	2	+ 60.45	+ 69.00
	3	+ 58.30	+ 70.72
	4	+ 52.91	+ 71.84

Note: The average for 1933 was taken as a basis for the two variables. The percentage figures relative to the 1933 average were computed directly from table 5. The difference between the two columns indicates the order of the percentage change of the monetary multiplier. Again, the reader should be warned that the difference is not exactly equal to the percentage change in the monetary multiplier. Also, the difference tends to increase with the lenght of the period under consideration. This follows from the non-linear terms in the exact statement of the expansion of the difference formula. Still, relative orders of magnitude have not been essentially distorted by neglecting these non-linear terms.

should clearly understand the nature of the percentage changes stated. These percentage changes measure the change of the variable from a given quarter in a year to the same quarter in the next year (see formulae in the note attached to the table). This per annum percentage change of M is negative until the end of 1933. And until the end of 1933 the percentage change in m exceeds in absolute value the percentage change in B. Evidently, open-market purchases of many hundred millions of dollars were quite insufficient to compensate the collapse in m (due to k in particular). From the first quarter of 1934 the percentage change of B dominates unambig-

[1] The text pertaining to table 4 is strictly descriptive. No propositions were stated, but the description was deliberately suggestive so as to encourage certain hypotheses concerning monetary events. Some of these which are relevant for our purposes will be taken up and others, particularly those relating to events in 1932/3 will be postponed to a later occasion.

uously. What happens to M is in the first instance a result of B's behavior. There is a significant difference in the order of magnitude of the percentage change in B and in m. This situation terminates with the first quarter of 1937. The percentage change of m is in the second quarter of 1937 already half as large (absolutely) as B's percentage change. In the third quarter the two percentage changes are of the same order and in the fourth quarter the value of m has surpassed the corresponding value of M. The negative percentage change in M at the end of the period is the joint result of two events: the rise in reserve requirements depressing m and the severe contraction in the percentage change of B.

Table 6 confirms the pattern established. The two columns measure percentage changes of M and B relative to their average value in 1933. Until the Federal Reserve's decision to raise reserve requirements in the third quarter of 1936 M and B move concurrently by similar orders of magnitude. From the third to the forth quarter of 1936 there is a noticeable jump in the difference between the two columns from 2.14 to 6.82. This difference rises further to 7.17, 8.55, 12.42, and 18.93. While this difference is not equal to the percentage change in m (relative to 1933) for reasons indicated in the note to the table, the two magnitudes are approximately proportional. Again, the table clearly marks the break in the monetary development which was brought about as a result of the Federal Reserve's policy in 1936/7.

4. Table 7 amplifies the information in table 5. The four columns state the contribution of the four determinants of M which appear in the money-supply function to the percentage change in M. As table 7 is based on values of specified months and not on quarterly averages individual figures differ to some extent from corresponding figures in table 5. But orders of magnitude and general patterns are not affected by this shift in the nature of the data. It should be noted that the sum over a row in the table is approximately equal to the percentage change of the money-supply.

The change component of M attributable to r is negative throughout the period. It starts with — 9.11 % and moves to a low of — 12.17 % in September 1934. From the low of — 12.17 % the change-component of r rose to around — 6 % and further to about — 3 % to — 2 % in 1936. As a result of Federal Reserve policy the component fell again to around — 4% in 1937. The change component of k starts out with an impressive — 17.12 % reflecting the public's flight into currency. This deflationary force, while quickly declining, still lasts to the end of 1933. Early 1934 shows a radical change of situation. The change component jumped within 3 months from — 1.48 % to + 10.37 %. It immediately falls off again to a region of + 4%–+ 6 % where it stays until September 1935. At this point it starts on a gradual decline until the change component becomes negative again in June 1937.

The t component is always positive until June 1937. It turns negative simultaneously with k's change component. Until about June 1935 the t-component is of significantly smaller order than any of the other components and from this time on it is of approximately the same sign and order as the k-component. From the point on that the k-component turns positive, the sum of the last two columns compensates to a large extent the negative r-component. This compensation among the

Table 7. The Components of the Money-Supply Growth Rate

Quarter		Growth in money-supply due to B	Growth in money-supply due to r	Growth in money-supply due to k	Growth in money-supply due to t
1933	3	+ 10.87	— 9.11	— 17.12	+ .96
	6	+ 1.12	— 8.19	— 3.06	+ 2.92
	9	+ 1.23	— 8.34	— 1.48	+ 2.62
	12	+ 5.30	— 11.06	— 1.48	+ 3.13
1934	3	+ 8.37	— 12.00	+ 10.37	+ 2.54
	6	+ 17.50	— 11.52	+ 5.35	+ .73
	9	+ 21.75	— 12.17	+ 5.59	+ 1.86
	12	+ 18.34	— 8.94	+ 5.77	+ 1.62
1935	3	+ 17.39	— 6.76	+ 4.41	+ 1.84
	6	+ 16.84	— 6.03	+ 5.17	+ 2.86
	9	+ 17.07	— 5.65	+ 4.57	+ 2.76
	12	+ 19.63	— 6.65	+ 3.27	+ 2.32
1936	3	+ 13.72	— 3.83	+ 1.16	+ 1.62
	6	+ 13.71	— .64	+ 1.61	+ 2.17
	9	+ 14.93	— 3.13	+ 1.25	+ 1.37
	12	+ 13.97	— 2.15	+ .56	+ 1.58
1937	3	+ 15.29	— 4.71	+ .92	+ 1.09
	6	+ 11.14	— 6.40	— .61	— .72
	9	+ 6.45	— 2.76	— 1.25	— 1.79
	12	+ 3.09	— 4.21	— 2.11	— 2.78

Note: The percentage changes indicate the contribution of each one of the four determinants of money-supply to the percentage change in the money-supply from a given month in one year to the same month of next year. This was computed for March, June, September, and December in 1933–1937. The formulae used are

i) for the first column:

$$\frac{B - B_{-12}}{B_{-12}} \times 100$$

ii) for the second column:

$$\frac{1 + t_{-12}}{r_{-12}(1 + t_{-12}) + k_{-12}} \times (r - r_{-12}) \times 100$$

iii) for the third column:

$$\left(\frac{1}{1 + k_{-12}} - \frac{1}{r_{-12}(1 + t_{-12}) + k_{-12}}\right) \times (k - k_{-12}) \times 100$$

iv) for the fourth column:

$$\frac{r_{-12}}{r_{-12}(1 + t_{-12}) + k_{-12}} \times (t - t_{-12}) \times 100$$

three components (r, k, t) accounts for the small order of the percentage change in m relative to B. The relatively deflationary behavior of banks was thus practically nullified by the relatively inflationary behavior of the public with respect to the administration of its money and deposit balances.

Table 8. The contributions to the Growth-Rate of the Money-Supply relative to the Depression Trough (March 1933)

Month	Money-supply	Monetary-Base B	Currency-demand deposit ratio k	Demand-time deposit ratio t	Reserve-quotient r
December 1933 . .	+ 3.12	+ 2.63	+ 7.96	+ 1.97	— 9.44
June 1934.	+ 12.61	+ 13.35	+ 10.67	+ 2.21	—14.62
December 1934 . .	+ 19.75	+ 21.58	+ 13.37	+ 3.17	—18.37
June 1935.	+ 31.30	+ 32.44	+ 15.43	+ 4.08	—20.65
December 1935 . .	+ 41.07	+ 45.31	+ 16.30	+ 4.53	—25.07
June 1936.	+ 58.04	+ 50.61	+ 16.85	+ 4.27	—21.25
December 1936 . .	+ 60.46	+ 65.48	+ 16.79	+ 5.34	—27.15

Note: The sum of the figures in columns 2–5 is approximately equal to the first column figure. The difference is due to rounding error and dominantly to the non-linear terms in the difference expansion. The relative size of this non-linear term increases with the lenght of the period covered. The results were computed from the following formulae:

column 1: $$\frac{M_t - M_0}{M_0} \times 100$$

column 2: $$\frac{B_t - B_0}{B_0} \times 100$$

column 3: $$\left(\frac{1}{1+k_0} - \frac{1}{r_0(1+t_0)+k_0}\right) \times (k_t - k_0) \times 100$$

column 4: $$\frac{r_0}{r_0(1+t_0)+k_0} \times (t_t - t_0) \times 100$$

column 5: $$\frac{1+t_0}{r_0(1+t_0)+k_0} \times (r - r_0) \times 100$$

The subscript 0 refers to March 1933 and subscript t to one of the later months considered.

In table 8 the same decomposition in the growth rate of M is repeated with a different procedure. The four components in the growth rate of M are measured for specific months up to the first raise in requirements and relative to the depression trough in March 1933. A comparision of the first two columns exhibits a strong parallel movement of M and the B-component. For first approximations the B-component accounts for the behavior of M over the period. The k-component rises strongly at first until about the end of 1934 and slows down moving along only very gradually. The t-component moves in relatively small and gradual steps. It evidently is the least important of the four. The r-component is always substantial but not of significantly larger order than the sum of the k and t-component. Again, we observe the approximate compensation of deflationary bank behavior by inflationary behavior on the part of the public. The net effect of the three components is small relative to the B-component and consequently we obtain the close association between the data of the first two columns.

Table 9. The Determinants of the Monetary Base

Year	Annual averages of daily figures in billions of $						
	Monetary Base	Federal reserve-credit	Gold-stock	Treasury-Currency	Treasury-deposits at FRB	Other accounts	Treasury-cash
1932	7 442	2077	3 952	2096	39	407	236
1933	7 929	2429	4 059	2271	55	497	288
1934	9 079	2502	7 512	2381	81	438	2798
1935	10 586	2475	9 059	2478	128	477	2791
1936	12 090	2481	10 578	2503	446	551	2474
1937	13 305	2554	12 162	2567	158	595	3226

Note: All data are taken from "Banking and Monetary Statistics", p. 368. Board of Governors of the Federal Reserve System, Washington D.C., 1943.

Table 10. Percentage Changes of Monetary Base and its Determinants relative to 1933

Year	Monetary base	Federal reserve-credit	Gold-stock	Treasury-currency	Treasury-deposits at FRB	Other accounts	Treasury-cash
1934	14.52	+ .92	+ 43.54	+ 1.39	— .33	+ .74	— 31.66
1935	33.51	+ .58	+ 63.06	+ 2.61	— .92	+ .25	— 31.57
1936	52.47	+ .65	+ 82.22	+ 2.93	— 4.93	— .68	— 27.69
1937	67.80	+ 1.57	+ 102.19	+ 3.73	— 1.30	— 1.24	— 37.05

Note: The percentages are obtained from table 9. The reader may notice that a small discrepancy has appeared in the equation which is mostly due to rounding.

5. We accounted for the contribution of m and B to the behavior of M in the period 1932–1937. The contribution of m was further decomposed to establish that the relative unimportance of changes in m, observed for a major part of the period, is the result of opposite movements in the magnitudes shaping m. The only relevant influence is exerted by m in 1932/3 as a result of k's behavior and in 1937 as a result of r, induced by the rise in reserve requirements. By means of equation 1 we also decompose B's contribution to the growth rate of M. Table 9 presents annual averages of daily figures for the variables in equation 1 and clearly reveals the main forces behind the behavior of B. The volume of Federal Reserve Credit shows only

one major change (1932 to 1933). From 1933 onwards the variable F is practically constant. The volume C of Treasury currency shows a gradual and regular increase, small relative to the changes in B. The variables d and o (which includes also f) are also of small order with small variations. From 1933 on the gold accounts of "gold stock" and of "Treasury cash" dominate what happens to B.

Table 10—derived from table 9—shows the contribution of each variable in equation 1 to the percentage change in B relative to 1933. Only two columns really matter in the table: gold stock and Treasury cash. The sum of their percentage changes approximately equals the percentage change of B—the difference between the two magnitudes is of small order.

6. The variable "Treasury cash" became important as a result of the dollar devaluation in January 1934 [1]. This implied a revaluation of the stock of gold at the higher price of gold in dollars. As the dollar value of gold monetized through issues of gold certificates was not adjusted in the same manner, Treasury cash increased. As a matter of fact, it increased by an amount approximately equal to the increase in the dollar value of the stock of gold due to the dollar devaluation. The large jump in Treasury cash in 1934 thus reflects an essentially restrictive policy of the Federal Reserve Board at the very beginning of the upswing. By monetizing all the gold the monetary base could have been raised to a level 2510 million dollars higher than the one reached in 1934. As both tables, 9 and 10, indicate, some monetization of Treasury cash took place in 1936, precisely at a time when the Federal Reserve Board professed to be worried by possibilities of "injurious credit-expansions". Treasury cash was reduced by approximately 300 million dollars. Consequently, roughly one-third of the increase in B in 1936 was due to the monetization of previously free gold. Thus, one third of the growth of M attributable to B was generated by the monetization of free gold. Both tables indicate, thereafter, a reversal in this policy. Treasury cash increased in 1937 by about 750 million dollars and the percentage change (relative to 1933) falls from — 27.69 % to — 37.05 %. This behavior of c reflects the sterilization policy initiated by the Treasury and the Federal Reserve Board in December 1936.

7. Further details on the major components of equation 1 are assembled in table 11. Column 3 measures the portion of the gold accrual which is actually monetized. Throughout 1934 the amount monetized is substantially below the accrual. We observe a change in this situation in 1935: Monetization catches up with accrual and in the last quarter of 1935 is even greater. In 1936 monetization exceeds accrual in three quarters (1, 2, 4) and is slightly less than the inflow in the third. It should be remembered that the Annual Report on 1935, written in early 1936, already considered excess reserves as "too high" and suggested a close watch on the credit-situation. Monetization and accrual are still roughly equal in the first quarter of 1937—i. e. after the sterilization policy had been officially initiated. Then a sharp decline occurs in the relative degree of monetization.

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[1] The major element in Treasury cash is the free gold, i. e. the gold against which no gold-certificates have been issued yet. Gold stock minus free gold is the gold reserve – equal to the value of gold certificates issued.

Table 11. Changes in Federal Reserve Credit, Gold stock, Gold reserve, and Monetary Base in million of dollars, relative to some quarter in previous year

		F^1	A^1	$(A-c)^1$	B
1933	1	400	16	68	636
	2	364	107	24	514
	3	— 83	586	85	214
	4	333	7	— 22	293
1934	1	429	2.127	— 8	499
	2	147	3.749	1.022	1.275
	3	198	3.609	1.260	1.620
	4	— 113	4.040	1.377	1.507
1935	1	— 133	2.175	1.549	1.535
	2	— 8	1.035	1.168	1.194
	3	9	1.240	1.431	1.356
	4	21	1.722	2.177	1.890
1936	1	24	1.731	2.135	1.555
	2	3	1.540	1.885	1.190
	3	0	1.504	1.486	1.633
	4	— 3	1.308	1.515	1.672
1937	1	— 10	1.239	1.205	1.643
	2	81	1.578	1.058	1.866
	3	101	1.834	984	971
	4	118	1.672	420	388

Note: The figures are differences taken by subtracting from the value of a variable in a given quarter of 1933–1936 the value in the same quarter of the previous year. Gold reserve and Gold stock differ by the amount of gold in Treasury cash which forms the free gold not yet "mortgaged" by issues of gold certificates.

The Federal Reserve Board's policy on the degree of monetization of gold in this period is certainly informative as to the rationality of policy decisions. At a time when unemployment was still more than 20% of the labor force, real income more than 20% below levels previously reached, the Federal Reserve pursued a restrictive policy in form of a low degree of monetization. Two years later, when concern was expressed at the potentialities of inflation, the degree of monetization had been substantially raised. And one year later, at a time of sharp decline in aggregate demand and pronounced deflationary processes, the degree of monetization was radically lowered. The reader should also note the parallel motion of the annual monetization and the annual increment in the monetary base since the second quarter of 1934.

8. Tables 9–11 exhibited a complete dominance of B by A, more specifically by $(A-c)$. Every dollar of monetized gold eventually raised bank reserves by nearly a dollar [1]. As this increase in R of commercial banks was not the result of

[1] If the increase in A—c was simultaneous with the increase in A, then B rose immediately, and as k was falling, this increase in B mostly went to R. Until the middle of 1934 the annual increment of C^p was even negative, then it declined from $^1/_{30}$ of the annual increment in B to $^1/_8$ at the end of 1936. If the increase in $(A$—$c)$ was lagged relative to the increase in A, d will rise with $(A$—$c)$ and then it depends how rapidly the Treasury will use the funds acquired through monetization of the gold.

asset-sales by these banks to the Federal Reserve Banks, the increase in R due to monetization was immediately matched by an equal increase in deposits. According to the values of t and the average reserve requirements prevalent in the period, we compute that the increase in excess reserves induced by such increases in the monetary base would average at most 93 % of the increment in B. How large was this ratio actually and how did it behave?

Table 12. Changes in Volume of Excess Reserves and of Monetary Base relative to 1933 Average, in millon dollars

Quarters		Excess reserves = E	Monetary base = B	ratio $\frac{E}{B}$
1934	1	+ 497	+ 521	.95
	2	+ 1069	+ 1191	.90
	3	+ 1262	+ 1495	.84
	4	+ 1224	+ 1692	.72
1935	1	+ 1565	+ 2056	.76
	2	+ 1707	+ 2385	.72
	3	+ 2003	+ 2851	.70
	4	+ 2408	+ 3582	.67
1936	1	+ 2361	+ 3611	.65
	2	+ 2087	+ 3575	.58

Note: The period covered terminates with the last quarter before the first raise in reserve requirements. The figures were computed from data in "Banking and Monetary Statistics".

Table 12 answers this question. The ratio starts with .95. This small excess over .93 was mainly due to the flow of currency back from the public to the banks. But most important is the gradual decline of the ratio to .58 just before the rise in reserve requirements. The movement of the ratio implies that the degree of utilisation of quarterly increases in B in the form of a money-supply expansion was continuously rising, with a single exception in early 1935.

c) Construction of Empirical Money-Supply Functions

1. The statistical analysis of relevant orders of magnitude can be approached in a different way. The money-supply function expressed by equation 8 is non-linear in k, t, r and B. This function is expanded in form of a series around values $B = 0, r = 0, t = t_0, k = k_0$, so that t_0 and $k_0 > 0$ and smaller than observed values. We obtain thus

$$9.\ M = m_0 + m_1 B + m_2 r + m_3 k + m_4 t + 0$$

m_0 is equal to the expression $-m_3 k_0 - m_4 t_0$. The $m_i (i = 1, 2, 3, 4)$ are the derivatives of the M-function 8 with respect to the variables attached to m_i. In particular, m_1 is the monetary multiplier. As m_3 and m_4 are negative, it follows that m_0 is positive. 0 denotes the non-linear terms of the expansion.

Table 13. Money-Supply Functions based on Annual and Quarterly Data

Regressions	Simple correlations	Partial correlations	Multiple correlation
1. $M_1 = +12.22 + 1.38\,B_1$	$+.95$		
2. $M_1 = +7.61 + 2.13\,B_2$	$+.95$		
3. $M_1 = +9.78 + 1.71\,B_1 - .11\,r_1$	$r_{M,B_1} = +.95$	$r_{M_1,B_1.r_1} = +.84$	
	$r_{M,r_1} = +.81$	$r_{M_1,r_1.B_1} = -.10$	$+.95$
	$r_{r_1,B_1} = +.87$	$r_{r_1,B_1.M_1} = +.55$	
4. $M_1 = +13.57 + 2.01\,B_1 - .42\,r_2$	$r_{M_1,B_1} = +.95$	$r_{M_1,B_1.r_2} = +.90$	
	$r_{M_1,r_2} = +.81$	$r_{M_1,r_2.B_1} = -.61$	$+.97$
	$r_{r_2,B_1} = +.93$	$r_{r_2,B_1.M_1} = +.86$	
5. $M_1 = +9.21 + 2.91\,B_2 - .65\,r_1$	$r_{M_1,B_2} = +.95$	$r_{M_1,B_2.r_1} = +.87$	
	$r_{M_1,r_1} = +.81$	$r_{M_1,r_1.B_2} = -.46$	$+.96$
	$r_{r_1,B_2} = +.92$	$r_{r_1,B_2.M_1} = +.81$	
6. $M_2 = +4.52 + 1.97\,B_3$	$+.98$		
7. $M_2 = +5.91 + 2.13\,B_4$	$+.88$		
8. $M_2 = +4.43 + 2.16\,B_3 - .14\,r_3$	$r_{M_2,B_3} = +.98$	$r_{M_2,B_3.r_3} = +.97$	
	$r_{M_2,r_3} = +.72$	$r_{M_2,r_3.B_3} = -.42$	$+.98$
	$r_{r_3,B_3} = +.79$	$r_{r_3,B_3.M_2} = +.58$	
9. $M_2 = +14.35 + 1.90\,B_3 - .59\,r_4$	$r_{M_2,r_4} = +.89$	$r_{M_2,B_3.r_4} = +.97$	$+.99$
	$r_{r_4,B_3} = +.95$	$r_{M_2,r_4.B_3} = -.84$	
10. $M_2 = +4.13 + 2.48\,B_3 - .24\,r_5$	$r_{M_2,r_5} = +.89$	$r_{M_2,B_3.r_5} = +.94$	
	$r_{r_5,B_3} = +.94$	$r_{M_2,r_5.B_3} = +.52$	$+.98$
		$r_{r_5,B_3.M_2} = +.18$	
11. $M_2 = -1.72 + 5.70\,B_4 - 1.84\,r_3$	$r_{M_2,B_4} = +.88$	$r_{M_2,B_4.r_3} = +.97$	$+.99$
	$r_{r_3,B_4} = +.96$	$r_{M_2,r_3.B_4} = -.95$	
12. $r_4 = +1.13 + .73\,r_5$	$+.99$		
13. $r_4 = +.79 + .77\,r_3 + .69\,e$	$r_{r_4,r_3} = +.61$	$r_{r_4,r_3.e} = +.96$	
	$r_{r_4,e} = +.63$	$r_{r_4,e.r_3} = +.96$	$+.97$
	$r_{e,r_3} = -.19$	$r_{e,r_3.r_4} = -.93$	
14. $m = +2.961 - .0338\,r_4$	$-.823$		
15. $m = +4.37 - .0658\,r_4$	$r_{m,k} = +.40$	$r_{m,r_4.k} = -.926$	$+.99$
$-.0351\,k$	$r_{k,r_4} = -.836$	$r_{m,k.r_4} = -.974$	

Note: Equations 1–5 are based on annual data and cover the period 1929–1941. The variables are M_1 = average of seasonally unadjusted June–December figures. B_1 = monetary base (minus "other deposits") annual average of daily figures. B_2 = monetary base (excl. of "other deposits") minus excess reserves – both components of the difference are again annual averages of daily figures. r_1 = average of June–December reserve-requirements on demand deposits. r_2 = the sum of r_1 and the average of the June–December figures of the member banks excess reserve ratio (defined as excess-reserves divided by net demand deposits of member banks).

Equations 6–15 are based on quarterly averages of seasonally adjusted monthly figures for the period January 1932–December 1937. M_2 = quarterly average of seas. adj. monthly money-supply figures. B_3 = quarterly averages of seas. adj. monthly figures of monetary base (excl. of "other deposits"). B_4 = quarterly averages of the difference between seas. adj. monthly figures of monetary base and excess reserves. r_3 = quarterly average of monthly figures of (average) reserve-requirements on demand deposits. These requirements are an average of the three groupes of member banks. r_4 = quarterly average of monthly reserve-quotient of consolidated banking system. r_5 = quarterly averages of monthly data on the sum of the reserve requirements on demand-deposits and the excess-reserve-ratio. e = excess-reserve ratio (= ratio of excess reserves and net demand deposits). k = currency-demand deposit ratio of the public, seas. adj. m = monetary multiplier. Regression computations were based on value-figures expressed in billions of \$ and ratios were transformed into percentages. The "small" regression coefficients in equations 14 and 15 are simply a result of this choice of units. With ratios expressed as fractions the slope coefficients would become 100 times larger. Statistical significance of the regression slopes is reflected by the partial correlation coefficients.

We assume that the non-linear term can be neglected. This procedure impounds the systematic effects of B, k, t, and r on M which operate through the non-linear term of the expansion into the random residual already existing (but not specified) for the original money-supply function. A more disturbing effect of impounding a part of the systematic mechanism into the random component is the probably resulting rise in the degree of auto-correlation [1]. Ultimately, the decision to neglect the non-linear terms can be justified if it leads us to valid and useful propositions explaining the behavior of M.

2. The close association between M and B was repeatedly emphasized in the last section. Taking the period as a whole, B apparently was the most important single variable determining M. Thus, we construct a first approximation linearized M-function.

$$10.\ M = b_0 + b_1 B$$

which accounts for the observable behavior of M in terms of B only. Regressions 1 and 6 in table 13 refer to this case. The two regressions cover different periods and use also different measurement procedures for the variables involved (see note). Sample correlation is very high. In equation 1 the variations of B account for 90 % of the observable variation in M. According to equation 6 96% of the observable variations in M are "explained" by B's behavior. The regression-slopes of 1.38 and 1.97 are substantially below the average monetary multipliers computed for the respective periods. But simple reflection will indicate that the regression-slopes of 1 and 6 tend to underestimate the monetary multiplier and also that this underestimation is larger for 1. The M-function expressed by 8 can be drawn as a straight line through the origin in a coordinate system with B on the abscissa and M on the ordinate. The slope of the line is the monetary multiplier m. In the period 1929–41 m was mostly falling, i. e. the line was pushed to the right and for most of this time B was rising. Consequently, the scatter of points generated in this manner tended to lay across the bundle of lines, each line expressing an M-function with a specific m. As the period 1929–41, underlying 1, encompasses a lager range for m than the period 1932–37, underlying 6, the twist in the regression-

[1] The estimation of money-supply functions raises a number of econometric problems which will be investigated in the paper on "Monetary Theory and the Money-Supply Function".

line relative to the average m has been larger. Consequently, the regression-slope has been compressed more substantially. This twisting of the regression-line relative to the bundle of straight-line homogeneous M-functions is also clearly reflected by the free constant a_0 which is nearly three times larger for 1 than for 6.

3. The same phenomenon can also be explained in terms of the linear component of 9. By equating corresponding terms in 9 and 10 we obtain

$$11.\ b_0 = m_2 r + m_3(k-k_0) + m_4(t-t_0) + 0$$

In the previous section we observed that for the period 1932–37 the deflationary effect of r on the multiplier m exceeds the inflationary effect of k and t. Consequently, b_0 is gradually reduced over the period. This means that we obtain a family of parallel M-functions, differentiated by distinct negative b_0. If this family of lines is combined with a continuously growing B—so that larger B's are associated with lines in lower position—a scatter may be generated which lays across the lines with a regression-slope smaller than the slope of the lines and a larger free constant.

4. In regressions 3, 4, 8, 9, and 10 one or the other form of reserve ratio is added as an explanatory variable to the base. Again, the reader should be careful in distinguishing 3, 4 on the one side and 8, 9, 10 on the other—differentiated by periods and measurement of variables. Correlation is always high and indicative of a systematic connection. A comparison of correlation-coefficients shows that the introduction of reserve-ratios has no significant effect on the explanatory power of the M-function in terms of the total variation of M. The essential purpose is to specify the nature and order of magnitude of the dependence of M on various types of reserve ratios. Regressions 3, 9, and 4 have slopes markedly below the monetary multipliers observed for their period. 3 in particular has the lowest regression-slope with respect to B_1 and a slope with respect to r_1 (average reserve-requirements on demand deposits, June–December averages) which does not differ significantly (in a statistical sens) from null. The situation is distinctly improved in 4, covering the same period where the sum of reserve requirements and excess reserve ratio is used in lieu of the reserve requirements alone.

8 has the same general form as 3 and shows a better result than 3. The slope with respect to B has moved into the lower range of observed multipliers and the slope with respect to r has gained in significance. For 10 a regression slope with respect to B was obtained which approximates observed multipliers.

5. In all these cases the simple correlation between reserve ratios and M is positive, whereas the partial correlation is negative, as theory asserts it should be. The positive simple correlation reflects the joint dependance of M and r on B. r_2, r_4, and r_5 contain the excess reserve ratio which was swollen simultaneously with B by the gold inflow. Also r_1 and r_2 the average reserve requirements have been raised by these gold inflows, only to a much lesser extent. The capital flight to the US, being one of the major sources of the gold flow, tended to concentrate large amounts of foreign deposits at New York banks. This raised their relative amount of net

demand deposits and thus the average reserve requirements. If the joint dependence of the r's and M on B is removed, we find the expected systematic negative relation between the money-supply and reserve-ratios.

6. Regressions which contain only B or B and r_i ($i = 1,3$) are useless for the analysis of changes in the banks' excess reserve position. 4, 9, and 10 include the excess-reserve ratio in one form or another in the reserve-variable r used by these equations. Another way to obtain linear regressions of M-functions which account explicitly for excess reserves is the following procedure: The volume E of excess-reserves is separated out as an exogeneous variable. The simple M-theory assumes the following form:

$$12.\quad B = E + R + C^b + C^p$$

$$13.\quad R = b_1 r^d . D^p + b_2 r^t T$$

$$14.\quad C^b = a_0(D^p + T)$$

$$15.\quad T = t D^p$$

$$16.\quad C^p = k D^p$$

$$17.\quad M = C^p + D^p$$

where R = required reserves. b_1 = the ratio of net demand deposits of member banks to demand deposits adjusted of all commercial banks. b_2 = the ratio of time deposits of member banks to total time deposits of all commercial banks. Solving for M we derive

$$18.\quad M = \frac{1 + k}{a_0 + b_1 r^d + t(a_0 + b_2 r^t) + k} \times (B - E)$$

By the same process of expansion and dismissal of non-linear terms we obtain

$$19.\quad M = n_0 + n_1(B - E) + n_2 r^d + n_3 r^t + n_4 k + n_5 t$$

To shorten the expressions r^d and r^t can be combined into one variable or r^t completely dismissed. As r^t and r^d have usually been changed together and often in the same proportion, r^d can be interpreted as an index of the total reserve requirements.

7. Regressions 2 and 7 show the simplest approximation to the above formula. In both cases the regression-slope is again lower than the average observed multiplier. But, as it should be, it exceeds substantially the slopes of the corresponding regressions 1 and 6. This difference between regression-slopes reflects the difference between the multipliers in 8 and 18. Regressions 5 and 11 add the reserve requirements to the net monetary base ($B - E$). They form a second approximation to the linear component of the second form of simple M-theory. Both regressions show substantially larger slopes with respect to B than 2 and 7. Also, the regression-slopes with respect to r_1 and r_3 exceed very clearly the corresponding slopes (in absolute magnitude) of 2 and 7. It is probable that regression 11 overestimates the effect of B on M. This surmise follows from the following consideration: Let

b_0 be the free constant in regression 11 and conceive of r^d as an index of reserve requirements. Also, assume the linear expansion in 19 to be at the values $B-E=0, k_0$ and $t_0=0$ smaller than observed values. Then we obtain

$$20.\ b_0 = n_3(k-k_0) + n_4(t-t_0) < 0$$

Over the period 1932–37 k and t are mostly falling, thus, b_0 is in general rising. Consequently, the intercept of the plane while negative, is increasing over the succession of quarters, while at the same time $B-E$ rises. This combination of circumstances produces a scatter whose regression plane cuts across (from above) the bundle of planes, generated by variations in b_0. As a result the regression-slope is an *exaggerated* estimate of the slope of the planes in the bundle. Because the period 1929–41 contains some years with rising k and t (1929–32) excluded from the computational basis of 11 the twisting of the regression-plane across the bundle of "true" planes does not arise to the same extent and for 5 the regression slope with respect to B is probably nearer the mark than in case of 11.[1]

8. A last approach to the estimation of M-functions derived from 8 takes the form of a partial linearization. Instead of searching for an approximation of M which is linear in B, r, k, and t, we restrict our investigation to an approximation of m which is linear in its determinants. We consider at this place only the multiplier specified by the first of the two M-theories. From 8 we know that m is a non-linear function of r, k, and t. Regressions 14 and 15 show two different linear approximations to m: 14 considers only the reserve-quotient and 15 both, reserve quotient and currency-ratio k. The correlation-coefficients of the two cases differ substantially. Evidently, the explicit incorporation of k into the regression improved the degree of explanatory power of the approximation. It is also significant that the regression-slope with respect to the reserve-quotient is nearly twice as large in 15. An evaluation of this difference can be based on the full linear component of the m-expansion.

$$21.\ m = c_0 + c_1 r + c_2 k + c_3 t$$

If the expansion is made at the values $r = o$, $k = k_0$, and $t = t_0$, both, k_0 and t_0 positive and smaller than observed values then we have the following relations

$$22.\ a_0 = \frac{1+k_0}{k_0} + c_2(k-k_0) + c_3(t-t_0) \qquad \text{for 14}$$

$$b_0 = \frac{1+k_0}{k_0} + c_3(t-t_0) \qquad \text{for 15}$$

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[1] In order to evaluate this surmise the following more extended form of the M-function under consideration was estimated

$$M_2 = m_0 + m_1 B_4 + m_2 r_3 + m_3 k$$

All coefficients had the proper signs consistent with the theory and the monetary multiplier had been quite considerably reduced by the explicit incorporation of the variable k. The computations resulted in $m_1 = +1.72$ instead of the high value of $+5.7$.

Over the regression period (1932–37) both k and t fell in general, so that both a_0 and b_0 were rising. But a_0 was rising more than b_0 due to the presence of the k-term in a_0. As $m > 0$ and $c_1 r < 0$ it follows that $a_0 > 0$, and for a similar reason b_0 is also positive. As before, we obtain in both cases a bundle of lines or planes differentiated according to the free constant. And the larger a_0 the larger in general was also r. As a result, we obtain a scatter whose regression cuts across from below the downward sloping lines of the bundle in case 14. A similar argument holds in principle for the regression relative to the downward sloping planes in case 15. But, there is a major difference: In case 14 the regression slope underestimates considerably the effet of r on m, whereas in case 15 the regression slope of r is free of the distorting effect of k. The effect of t—which is still excluded—is of smaller magnitude. But to some minor extent it distorts the slope with respect to r (numerically) downwards and the slope with respect to k (numerically) upwards. This distortion left in regression 15 is probably small relative to sampling variations. The difference between a_0 and b_0 clearly accounts also for the observed difference between the free constants in regression 14 and 15. Due to the presence of the k-term in a_0 we have the inequality $a_0 < b_0$.

9. Regressions 12 and 13 describe two different approximations to the reserve-quotient. Both give excellent results. The order of magnitude of the regression-slopes in both cases match very well, even if some minor over-estimation may be suspected because of patterns of events not considered by the approximation. Correspondingly, there is some underestimation of the free constants.

By combining with the equation underlying regressions 18, 15, and 13, we obtain an estimate of the money-supply function with the following characteristics

$$23.\quad M = 4.318\,B — .0518\,r^d B — .0454\,eB — .0354\,kB$$

The derivative of M with respect to r^d is — $.0518B$ and with respect to e — $.045B$. Both are approximately of the order of the coefficient for r_1, r_2, r_4 in regression 4, 5, and 9. And the derivative of M with respect to B is the estimate of the monetary multiplier as a function of its main determinants. The dependence of the derivatives of 23 on B, r^d, e, and k—which clearly corresponds to the situation described by 8—seems to indicate some preference on purely a priori grounds for this partially linearized approach over the completely linearized one. Whether this is actually justified can only be established by a special investigation [1].

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[1] Two points should be noted here:

i) The M-functions estimated contain an element of spurious correlation as both B and M are defined in such a manner that they include a common component C^p. For purposes of testing hypotheses about the nature of M-functions this spurious correlation has to be removed. A simple way to do so is to investigate D^p as a function of B. The results for the post WWII period show that the degree of spurious correlation, introduced by the first formulation, is negligible.

ii) An extended econometric analysis is actually required to evaluate the relative usefulness of various forms of M-functions.

V. Excess-Reserves and Inflation

A. Formalization of the Problem

The quantitative information offered by the Federal Reserve Board to justify the raise in reserve requirements, summarized in part II, was restricted to estimates concerning the upper limit of a possible expansion of the money-supply generated by the volume of excess reserves. These estimates of the upper limit vary between approx. 80% and 140% of the money-supply existing at the time. The reason for these divergences is not very clear, it may be due to some extent to the circumstance that gold accruals expected in the near future were added to the already existing excess reserves. There is not doubt that such an expansion might have been *possible* but the crux of the matter is that an expansion of the money-supply approximately equal to its upper limit determined by the average reserve requirement is so improbable that we can dismiss its occurrence. This conclusion is at least strongly suggested by the last sections.

In order to obtain a better quantitative evaluation of the inflationary problem posed by excess reserves, a simple scheme is constructed which enables us to utilize the information gathered in part IV. We start from the equation of exchange $MV = Y = PX$ where Y is gross national product and V = velocity, P = price-level, X = real output. The nature of V is specified by the measurement rules for M and Y. By logarithmic differentiation we obtain

$$m + v = p + x$$

where the small letters all indicate the relative time rates of change of M, V, P, and X. To prepare the application of estimated values the four variables m, v, p, x will be interpreted as percentage changes from a specific month or quarter in year $t-1$ to the same month or quarter in year t. The non-linear terms arising in a difference expansion are impounded into p. This will exaggerate to a minor extent our measure of the degree of inflationary danger associated with a given volume of excess reserves. This measure is denoted by p_1. v denotes the maximum percentage increase in V which could reasonably be expected over a year of monetary expansion. m is the percentage change in the money-supply which can reasonably be expected on the basis of given excess-reserves. x is an estimate of the percentage rise in real output required to realize full-employment. The total price-movement p is decomposed into two parts, with radically distinct economic interpretation. p_2 is the price-movement associated with the increase in real output to full employment levels. $p_1 = p - p_2$ ist the purely inflationary component of the price development. The "degres of inflationary danger inherent in the given volume of excess reserves" can then be stated by the formula

$$p_1 = m + v - p_2 - x$$

B. Evaluation of Orders of Magnitude

1. The formula derived can now be applied to the situation existing in the summer of 1936. Suppose banks had started to utilize the available excess reserves. What is then a reasonable evaluation of the purely inflationary increase in prices

which would have resulted until the summer of 1937 ? This evaluation of p_1 hinges of course on our estimation of the component variable m, v, p_2, and x.

We start with x and use for this purpose a very rough and ready measure. According to table 2 there still existed a rate of unemployment of 10% in 1937. This figure is taken as a measure of x. This procedure overestimates on the one hand x by neglecting that even in full employment some small percentage of unemployment remains. On the other hand it underestimates x through its neglect of short hours and the extension of actual working time of a sizable portion of the already employed, usually associated with full recovery. Furthermore, the output-expansion permitted by the average annual productivity-increase has also been omitted.

An estimate of p_2, the price increase associated with an output-expansion, can be obtained from the first two regressions in table 3. According to these regressions a 10% increase of industrial production would raise the cost of living index by 2.7% and the index of wholesale prices by 5.1% [1]. By averaging the two percentages roughly in the proportion of consumers and investment expenditures we obtain a figure of 3,5%. Two considerations lead me to suspect that this output induced rate of price increase, associated with x, is an underestimate. First, variations in the index of industrial production are in general relatively larger than the associated variations in total real output. And secondly, on a more speculative basis, the classical theory of the firm suggests that the price-fixation function should have a non-linearity at some point towards full-employment so that a branch with a steeper slope would become relevant for outputs above some specific level. For these reasons the figure for p_2 is taken at a round 4%.

2. The previous figures were in the nature of reasonable guesses of most probable values of x and p_2. In the case of v such an assignement requires more information on the behavior of income-velocity. We desire a figure for v which is as small as possible and unlikely to be exceeded. In order to determine such a number we consider a sample of data on income velocity, pick out the positive changes in V from a quarter in a year $t-1$ to the same quarter in year t, compute the percentage increase in V relative to the smaller value and construct a frequency distribution of the subsample of positive percentage changes.

The sample period underlying the table includes three periods of strong inflationary pressures reflected in the behavior of V: 1940–43, 1946–48, and 1950/1. Thus, the distribution is barely biased in favor of small percentage changes by the choice of the sample period.

The sample data suggest that a percentage rise of more than 16% is unlikely to occur. We could certainly use this figure as our benchmark for the upper range of reasonably expected p. a. increases in velocity. Some additional considerations permit a further restriction of this indicator. A casual inspection of various samples

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[1] The reaction-elasticity of C and P with respect to π is $\frac{dC}{\pi}\frac{\pi}{C}$, $\frac{dP}{\pi}\frac{\pi}{P}$. The derivatives are .22 and .4. The ratios multiplying the derivatives are obtained by using values of the indices for the second quarter of 1936.

Table 14. Distribution of 37 observations of percentage increases in Income-Velocity [1]

Interval	Frequencies
0–4%	8
4%–8%	14
8%–12%	9
12%–16%	5
16%–20%	1
	37

of different types of velocity figures suggested the hypothesis that the p. a. percentage increase in V is systematically *negatively* associated with the existing level of V. A rank correlation test of significance was applied to the data with the result that the Kendall correlation coefficient was found to be — .32 with associated level of significance of .0054. This small probability of the observation given the null-hypothesis (no correlation) indicates that we can safely accept the hypothesis of a systematic negative connection between the two variables. We observe further that 9 observations out of a sample of 37 show percentage changes exceeding 10%. 6 of these 9 observations are counted in the highest two intervals of table 14. All 9 observations of a size exceeding 10% occur in quarters when income-velocity is substantially below the 1936/7 level. Consequently, the occurrence of a velocity-change in 1936/7 with an order of magnitude corresponding to these 9 cases was not very likely. But in order to leave some safety margin to our conclusion we choose as a benchmark not 10% but 12%. The value of v to be inserted in our formula is now obtained by subtracting the actually observed percentage change of V from 1936 to 1937 ($= 7\%$) from the upper benchmark which cuts out an unlikely range of possible velocity-changes: The result is a value of $v = 5\%$.

3. We are left with the estimation of m, the percentage increase in the money-supply which could be reasonably expected if the available volume of excess reserves were fully utilized. This figure was estimated in 7 different ways and the results are presented in table 15. The numbers in the column heading indicates which of the regressions in table 13 was used to compute the figures in the particular column. For equations which involve the net monetary base $(B - E)$ it was assumed that $\Delta E = -E$ and for the equations with the excess reserve ratio e it was assumed that $\Delta e = -e$. In both cases the change in money-supply was computed by multiplying ΔE and Δe with the proper coefficients. $\Delta M \times 100$ was then divided by M and this M-value was taken from the same quarter as all other values of variables in the formulae specifying ΔM. The ΔM and $\Delta M \times \frac{100}{M}$ computed from initiating

[1] V was defined as the ratio of seasonally adjusted quarterly GNP at annual rates in current $ to the quarterly averages of seasonally adjusted money-supply figures. The sample consisted of all quarterly V-data for the period 1/1939–4/1956. From this sample changes of V were computed from quarter t to quarter $t + 4$. Then all non-positive changes were dismissed and the positive changes were expressed as percentage changes relative to the smaller figure.

Table 15. Estimates of Increase in Money-Supply permitted by Volume of Excess-Reserves according to Regression Equations and Monetary Multipliers

Quarter		Increase in M in bill. \$ according to:							Percentage increase in M according to:						
		2	4	5	7	9	13 + 15	Monetary multiplier	2	4	5	7	9	13 + 15	Monetary multiplier
1934	1	1.1	1.0	1.5	1.1	.9	.8	1.0	5.6	5.1	7.7	5.6	4.6	4.1	5.0
	2	.8	1.1	1.0	.8	1.1	.9	1.1	4.2	5.8	5.3	4.2	5.8	4.7	6.0
	3	1.2	1.7	1.6	1.2	1.6	1.4	1.7	6.4	9.2	8.5	6.4	8.5	7.4	9.2
	4	1.6	2.3	2.2	1.6	2.2	2.0	2.3	8.3	12.0	11.4	8.2	11.4	10.4	12.0
1935	1	2.2	2.8	3.0	2.2	2.8	2.6	3.1	10.8	13.8	14.8	10.8	13.8	12.8	15.2
	2	3.4	4.1	4.7	3.4	4.0	3.9	4.5	16.2	19.5	22.4	16.2	19.0	18.6	21.4
	3	3.9	4.3	5.3	3.9	4.3	4.4	5.0	17.8	19.6	24.2	17.8	19.6	20.1	22.7
	4	3.8	4.0	5.2	3.8	4.0	4.2	4.8	16.7	17.5	22.8	16.7	17.5	18.4	21.4
1936	1	4.5	4.6	6.1	4.5	4.5	4.9	5.9	18.7	19.1	25.3	18.7	18.7	20.3	24.4
	2	4.8	4.6	6.6	4.8	4.6	5.1	6.2	19.3	18.5	26.5	19.3	18.5	20.5	24.7
	3	5.4	5.3	7.4	5.4	5.0	5.9	6.9	20.6	20.2	28.2	20.6	19.1	22.5	26.3
	4	6.3	5.7	8.6	6.3	5.6	7.0	7.8	23.3	21.1	31.9	23.3	20.7	25.9	29.1
1937	1	6.2	5.7	8.5	6.2	5.6	7.2	8.2	22.6	20.8	31.0	22.6	20.4	26.3	29.9
	2	5.6	—	7.7	5.6	—	—	—	19.4	—	26.6	19.4	—	—	—
	3	5.1	4.2	7.0	5.1	4.1	5.5	6.4	17.1	14.0	23.4	17.1	13.7	18.4	21.3
	4	4.4	3.5	6.1	4.4	3.5	5.1	5.4	14.5	15.1	20.1	14.5	15.1	16.8	17.7

Note: The volume of excess reserve or the excess-reserve ratio in the quarters 1/1933 to 4/1936 has been used to compute the increase in M which would occur if the total volume of excess-reserves would be utilized. The computation-formulae are

i) $\Delta M = m \times \Delta E$ where $\Delta E = -E$ col. 2, 5, 7

ii) $\Delta M = m \times \Delta e$ where $\Delta e = -e$ col. 4

iii) $\frac{\Delta M}{M} \times 100 = \frac{1+t}{r(1+t)+k} \times .7 \times \Delta e$ $\Delta e = -e$ last col.

iv) $M = m \times .7 \times \Delta e$ col. 9

v) $M = m \times B \times \Delta e$ col. 13 and 15

m refers to the respective regression-slopes. iii) gives us directly the percentage change and ΔM is obtained by multiplying with $\frac{M}{100}$. If values of quarter t have been used to compute ΔM or $\frac{\Delta M}{M} \times 100$, then the result is associated with $t + 4$.

quarters t were then associated in the table with quarters $t + 4$. This corresponds to the notion of a monetary expansion generated over a 12 month period. Regression 11 has not been considered in table 15 as the regression-slope with respect to the net monetary base has been distorted significantly above the true level of the appropriate monetary multiplier by the neglected variations of the k-variable.

All columns show substantially the same pattern over time. The results obtained according to regression 5 and by the differential of equation 8 with respect to e tend to agree very closely with the exception of a few figures in the first quarters. Also, their estimates form in general the upper range of the whole bundle of estimates. The figures obtained by regression 2 and 7 form the lower range of the bundle until about 1/1936 and from this period on they are joined by 4 and 9. The partially linearized M-function derived from 13 and 15 generates, in general, results somewhere in the middle range.

In order to determine how much our information on relevant orders of magnitude has been restricted by the results obtained we select from every row of percentage changes the smallest and the largest figure and arrange them in table 16 thus:

Table 16. Pairs of Lowest and Highest Figure of every Row in Table 15

lowest .	4.1	4.2	6.4	8.3	10.8	16.2	17.8	16.7	18.7	18.5	19.1	20.7	20.4	19.4	14.0	14.5
highest .	7.7	6.0	9.2	12.0	15.2	22.4	24.2	22.8	25.3	26.5	28.2	31.9	31.0	26.6	23.0	20.1

Table 16 exhibits a spread between highest and lowest which is approx. 40% to 50% of the lower figure. It is certainly desirable to narrow down this spread. A detailed analysis of the different forms of M-functions may help to contract considerably this region of uncertainty. For our purposes we simply consider the results as our information pattern. The real issue at this point is whether or not the subset H_1 concerning the laws of reaction of M to certain underlying changes has been established sufficiently narrow for intelligent policy-decisions. It is asserted that it significantly compresses the information-region supplied by monetary theory and Federal Reserve publications.

By using the lowest and the highest figure for m in the row associated with the second quarter of 1937 we obtain a reasonable range of evaluation of the "degree of inflation permitted by the volume of excess reserves" in the quarter just before the first raise in requirements.

$$\text{lower end of the range} = p_1 = 19 + 5 - 10 - 4 = 10\%$$
$$\text{upper end of the range} = p_1 = 27 + 5 - 10 - 4 = 18\%$$

We conclude thus that the full utilization of excess reserves in the period 1936/7 would have generated an inflation a degree of approx. 18 % at most p. a. in term of non-output induced price increases.

4. It is important to understand precisely what has been established thus far. This can be summarised in the follwing proposition: "If $\Delta E = -E$ (or $\Delta e = -e$) over the period 1936/7, then there would have resulted an inflation of degree at most 18% p. a." But the validity of this statement does not assure its relevance. This depends on the probability-value we can assign to the antecedent of the conditional. A definite assignment follows from the application of *Bayes'* postulate to the fundamental set of percentage changes in e (always taken relative to the larger component of the difference). Such an assignment seems to me to have been implicitly made in many policy-discussions. We often find a description of a set of outcomes by means of possibility-statements with a policy-conclusion attached. To derive

such a conclusion intermediate steps are required and such steps are supplied by *Bayes*' postulate and some minimax (or similar) strategy. The Federal Reserve's reasoning quoted in part II suggests strongly some logical pattern of this kind as a rationalisation of its inflation-conscious decision at a moment of total absence of actual inflationary motions. A chi-square test was made to consider the reasonableness of *Bayes*' postulate. For this purpose 320 observations of percentage changes of e between corresponding months of adjacent years in the period 1929 to 1956 were made. Their frequency distribution is given in table 17.

Table 17. Frequency Distribution of monthly p. a. relative changes in the excess-reserve ratio e

interval . . .	—1.0	—.9	—.8	—.7	—.6	—.5	—.4	—.3	—.2	—.1	0
frequencies .			1	6	22	9	28	23	38	41	41
interval . . .	+.1	+.2	+.3	+.4	+.5	+.6	+.7	+.8	+.9		
frequencies .	24	28	10	11	15	9	9	4	1		

The nullhypothesis states that any percentage change of e is just as likely to occur in one of the 20 intervals as in the other. Chi-square is 189 and with 19 degrees of freedom we find an associated level of significance way below .001. Consequently, it would be quite unreasonable to accept *Bayes*' postulate for the percentage changes in e. In particular we notice that extreme values of percentage changes in e are unlikely to occur. The Federal Reserve's implicit policy-reasoning has thus no empirical foundation. Also, we realize that the antecedent of the proposition stated above is rather unlikely to occur. As a result the range of a reasonably to be expected degree of inflation associated with the monetary situation of the summer 1936 can be further restricted. The frequency distribution in table 17 suggests that percentage changes in e exceeding 70 %—particularly downwards—may safely be considered as an unlikely event. If we recompute the upper and lower range of the "degrees of inflation" p_1 according to the specification $\Delta e = -e \times .7$ we obtain the following results:

$$\text{lower range} \quad p_1 = +4\%$$
$$\text{upper range} \quad p_1 = +10\%$$

After this adjustment the maximal degree of inflation associated with the excess-reserve basis in 1936 does not appear so impressive any more.

5. The Federal Reserve policy conceptions contained an element whose application to our problem compresses still further the relevant degree of inflation: According to descriptions of FR-policy the crucial portion of excess-reserves, the "non-controllable amount" was the difference between excess-reserves and the Federal Reserve's open-market portfolio. This magnitude is denoted by S_1 in Table 18.

There are only four quarters with positive values for this variable and the largest percentage change in the money-supply resulting from this first definition of "non-controllable excess-reserves" is approx. 6%. This would not even have been sufficient to restore full-employment, as can be seen by the inequality $m + v =$

Table 18. Estimates of the Increase in Money-Supply associated with various Definitions S of the "Non-controllable Component" of Excess-Reserves according to Regression 5

Quarters		S_1		S_2		S_3		S_4	
		increase in bill. $	percentage increase	increase in bill. $	percentage increase	increase in bill. $	percentage increase	increase in bill. $	percentage increase
1935	1			.5	2.1	.1	.4	1.6	6.6
	2			.9	3.6	.1	.4	1.9	7.7
	3	.3	1.2	1.8	6.9	1.0	3.8	2.5	9.5
	4	1.5	5.6	3.0	11.1	1.8	6.7	3.3	12.2
1936	1	1.4	5.1	2.8	10.2	1.8	6.6	3.0	10.9
	2	.6	2.1	2.0	4.2	1.2	4.2	2.1	7.7
	3			1.4	4.7	.7	2.3	2.2	7.4
	4			.5	1.6	.1	.3	1.6	5.3
1937	1 and 2			.6	1.9			1.6	5.2
	3 and 4							.2	.7

Note: For the years 1935 and 1936 the periods indicate quarters. For 1937 the first period includes January and February, i. e. the two months before the second raise in requirements and the second period includes March and April, i. e. the two months between the second and the third raise in requirements.

The definitions of the "non-controllable" component of excess-reserves are

S_1 = excess-reserves-portfolio of US gov. securities of FR. $S_2 = S_1 + .5$. S_3 = excess reserves × .7 – (US gov. securities — 1). S_4 = excess-reserves × .7 – (US gov. securities — 1.5). Definition S_1 is immediately given by FR statements concerning the crucial magnitude of excess-reserves. Definition 2 assumes a safety margin of 500 million $ in the FR's open-market portfolio. Definition 3 follows from two considerations:

i) p. a. percentage changes of excess-reserves exceeding 70% are very unlikely.

ii) the FR maintains a safety-margin of 1 billion $ for its open-market portfolio.

S_4 expresses the same idea except with a safety-margin = 1.5.

Every S^i is multiplied with 2.91 (the regression-slope of 5) and the result is associated with the month in which a change of the given size could have been initiated.

$11 < p_2 + x = 14$. And in the last quarter before the raise this discrepancy became quite pronounced. Thus, the non-controllable excess-reserves posed actually no problem of inflation.

The first definition of such a crucial component of excess-reserves assumes that the Federal Reserve Board should not maintain a safety-margin for the open-market portfolio in preparation for unexpected emergencies. In order to take account of such a safety margin a second definition of "non-controllable" excess reserves was used which considers the difference between excess-reserves and the open-market portfolio minus half a billion dollars worth of securities. The column under S_2 shows the results. The maximum percentage change has jumped to approx. 11% which together with $v = 5$ would just about have raised the economy to a full-recovery level. And in the early summer of 1936 this percentage increase had fallen to 4.2. This indicates that the Federal Reserve Board could have coped successfully with any actually arising inflation problem due to $\Delta e < o$ and, incidentally, let the economy move nearer full recovery by complete reliance on its open-market portfolio.

The case for this argument becomes even stronger when we consider the situation under the variables S_3 and S_4. Both are defined in such a way so as to exclude the unlikely event of a more than 70 % contraction of e per annum. Also, in the case of S_3 a safety-margin of 1 billion dollars and in the case of S_4 a margin of 1.5 billion dollars has been assumed. Thus, the third definition considered at most 60 % of the available open-market portfolio as a magnitude disposable over a 12 month period and the fourth definition at most 40 % of the portfolio. The largest percentage increases in the money-supply according to S_3 and S_4 occur in the fourth quarter 1935. S_3 would have left a small deflationary gap, whereas the upper range of the degree of inflation associated with S_4 is 4%. And in the summer of 1936 when the Federal Reserve Board judged the situation to have a greater inflationary potential than in 1935, the upper expansion range of approx. 8%, corresponding to S_4 was barely sufficient to push the economy to a full-employment level. This is shown by the inequality

$$m + v = 8 + 5 \leqslant 4 + 10 = p_2 + x$$

A quantitative analysis of the monetary situation in the summer of 1936 thus reveals how spurious the basis for a rise in reserve requirements actually was. "Injurious credit-expansions" are certainly always *possible*. But the results presented indicate that barring very unlikely variations in e, the Federal Reserve had an open-market portfolio sufficiently ample to break an inflationary motion while at the same time permitting excess-reserves to contribute towards a monetary expansion still needed to achieve a fully employed economy.

The Federal Reserve's deflationary bias is further shown by the development after the summer of 1936. The monetary expansion corresponding to S_4 in the fourth quarter of 1936 and the first two months of 1937 still leaves open a deflationary gap of 4%. Nevertheless, reserve requirements were raised a second time on March 1, 1937. The monetary expansion associated with S_4 in the two months following this second raise is indicated to be less than 1%, generating a deflationary gap of 8%. And still, the Federal Reserve raised requirements a third time on March 1, 1937 in order to "prevent injurious credit-expansions".

VI. Concluding Remarks

1. Monetary theory contains two conflicting hypotheses on the position of excess-reserves in the money-supply mechanism: One asserts that excess reserves are a pure surplus with no effect on the loan-supply function. Accordingly, excess-reserves play only a permissive function in a monetary expansion. The other hypothesis asserts that excess reserve have a relevant influence on the loan-supply function. Consequently, excess-reserves have a contributing function in a process of monetary expansion. No clear case has yet been established as to the relative

validity of the two hypotheses. Let us consider then the Federal Reserve's policy problem under both hypotheses.

If the "pure surplus hypothesis" holds, then a reduction in the excess-reserve-ratio *e* brought about by an increase in reserve requirements will only compress the limit of the monetary expansion permitted by excess-reserves without otherwise exerting a deflationary effect on the current expansion process. According to the orders of magnitude discussed in the last section of part V existing excess reserves could have permitted a degree of inflation up to 18% p. a. Additional information indicated that barring very unlikely behavior of *e*, any potential inflationary movement could have been prevented while permitting an expansion sufficient to restore full recovery—without any raise in reserve requirements.

If what may be termed a price-theory hypothesis of the position of excess-reserves holds, then a reduction in *e* due to an increase in requirements will actually exert a deflationary effect on the current expansion. But such a deflationary obstacle to the restoration of full employment was quite unnecessary as an anti-inflationary move. Thus, in summary, we find that in one "world" a rise in reserve-requirements would have been harmless and unnecessary and in the other "world" harmful and unnecessary. Rational decision in case of uncertainty as to the "world we live in" would definitely suggest not to raise reserve requirements in such circumstances.

2. The deflationary bias of the Federal Reserve Authorities is clearly revealed when we consider the Federal Reserve's contribution to monetary expansion in the 30's. The raise in requirements in 1936/7 is an integral part of such bias. The interval 1932–37 contains only a short period of 4 quarters where *B* rose as a result of Federal Reserve action expressed by *F*. In 1932 *B* was raised by approximately 11%. But this increase was quite insufficient to compensate the collapse in the monetary multiplier due to deflationary behavior by public and banks. The expansion in the money-supply from summer 1933 until the first quarter of 1937 was dominated by the gold inflow. During the whole upswing Federal Reserve policy, expressed through variations in Federal Reserve Credit and reserve requirements, contributed nothing to the monetary expansion. The development of the degree of monetization of gold accruals is another symptom of Federal Reserve policy. This degree is small in 1934 when the rate of unemployment is still very high. It is increased by the autorities at a time when they complain about the inflation-possibilities of excess-reserves. And ultimately, after the money-supply passed its peak in early 1937 and a monetary contraction started, the degree of monetization was subsequently radically compressed.

The monetary contraction initiated in the first quarter of 1937 was the joint result of a significant reduction in the monetary multiplier from 2.41 to 2.17 over the period 3/1936–4/1937 and the marked slowdown in the rate of growth of the monetary base. And both events were the consequence of Federal Reserve action. The slowdown in *B*'s growth rate was the consequence of the lowered degree of monetization of gold and the monetary multipliers contraction was dominantly the result of the raise in reserve-requirements. Thus, this unnecessary increase in requirements contributed to the monetary contraction initiated in early 1937.