A STUDY OF PRICES, WAGES AND EMPLOYMENT IN FINLAND, 1957—1966

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AHTI MOLANDER

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[Suomen Pankin..]

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HELSINKI

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PREFACE

When I was first confronted with the problems considered in this study, Professor J. J. Paunio and Dr. Timo Helelä were my immediate superiors at the Bank of Finland Institute for Economic Research. It was due mainly to their stimulation and encouragement that I familiarized myself with this field of problems more thoroughly. The results of certain tentative experiments concerning the interrelationship between the price and wage levels were reported in my thesis for the degree of licentiate. Later on, when Professor Paunio served as the research adviser to the Institute and Dr. Helelä as its director, I had numerous discussions with them concerning the problems associated with my work, and these greatly affected the direction of my thought. The final form of this study was influenced quite decisively by my stay at the Massachusetts Institute of Technology as an ASLA Fulbright fellow during the academic year 1967—1968. This is clearly apparent from the references in my study, even though these are not an adequate indicator of the extent to which my friends over there contributed to the line of thought adopted in this work.

Professor Paunio's untiring interest and encouraging criticism during the late phases of my study decisively furthered its completion. I am also indebted to Dr. O. E. Niitamo, who read my typescript, made a number of helpful suggestions and gave me invaluable advice.

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The group of fellow workers and friends with whom I have had an opportunity to discuss the various special problems associated with this study is almost innumerable. I wish to mention, in the first place, Heikki Aintila, Pekka Korpinen, Kyösti Pulliainen and Markku Puntila, whose willingness to help and cooperate, and whose remarks and suggestions, have significantly contributed to the formation of this study. Mr. Seppo Lindblom also deserves to be mentioned in this context. During many years of friendship we have exchanged thoughts about our respective research problems, and these discussions have also influenced the present study. I have also had an opportunity to discuss the problems of this study with Reino Airikkala, Heikki Kunnas, Kullervo Marja-Aho, Kari Puumanen and Eero Tuomainen, to whom I wish to express my warm thanks. The entire staff of the Bank of Finland Institute for Economic Research I wish to thank for the creation of

the practical facilities necessary for this work. Mrs. Lea Honkanen assisted me in checking the calculations. Mrs. Riitta Jokinen gave me help in the processing of the data. Miss Sinikka Kujala and Mrs. Aira Kasanko drew the graphs. Mrs. Kaarina Mikkonen typed the text of the study. Miss Annikki Leukkunen, finally, was responsible for the many and various tasks necessary in the preparation of the text for the press.

Words fail when we wish to express our particular thanks to somebody. My particular thanks are due, first and foremost, to my wife, whose enduring patience has made it possible for me to bury myself in the world of scientific research for months. She has not merely been an onlooker, but has been with me in spirit throughout.

My particular thanks are also due to Mr. Jaakko Railo, who translated the text into English, but whose contribution was not solely one of a translator. I also wish to thank Miss Linda Shelley for her valuable assistance in rendering the text into English.

Finally, it is my agreeable duty to express my thanks to the Yrjö Jahnsson Foundation for a grant that broadened the financial basis of the study.

Helsinki, April 1969.

Ahti Molander

1. INTRODUCTION

In consequence of the accelerated rise of price levels in most industrial countries following the Second World War the study of inflation has occupied economists of the post-war era more than their pre-war colleagues. As a result, some of the previously held views regarding the properties of the inflationary mechanism have been revised. Old theories have not merely been reformulated, so as to fit the altered circumstances, but entirely new theories of inflation have also been created.

The traditional quantity theory has had faithful supporters, and new variants have been suggested by them. Attention has, however, mainly concentrated on two mutually exclusive sets of inflation theories. One emphasizes the importance of demand factors and the other that of cost factors in the inflationary mechanism.

The theories emphasizing the part played by demand factors consider the inflationary mechanism as if decision units on the demand side were responsible for the inflationary developments that have taken place. Therefore, such theories are termed excess demand theories, and an inflation due to excess demand is characterized as buyers' inflation. A variety of interpretations of excess demand theories have been proposed. The theories based on the traditional demand and supply analysis have, however, the following feature in common: shifts in the demand and supply curves of the commodity and labour markets are assumed to lead to demand and supply disequilibria that cannot be eliminated except through changes in prices and wages. Excess demand theories can be applied as inflation theories only in full employment situations, where the supply curve is vertical and only shifts in the demand curve are considered. The traditional excess demand hypothesis rests on the assumption of perfect competition, as it is the workings of the market mechanism that are supposed to force prices and wages to levels where market demand will equal market supply.[1]

1. If certain restrictive conditions are introduced, however, the excess demand hypothesis can be combined with the assumption of imperfect competition; see J. J. Paunio A Study in the Theory of Open Inflation, Helsinki 1961, pp. 58—59. Bent Hansen's analysis of inflation is based on the assumption of monopoly, and he defines excess demand as the difference between demand and supply at the price chosen by the monopolist. This definition rests on the assumption that the monopolist does not have knowledge of the demand curve for his product. Hansen also considers the excess demand hypothesis by postulating perfect competition. Moreover, he defines excess demand in monetary terms (price x the quantity of excess demand) rather than in quantitative terms (the quantity

The theories emphasizing the part played by cost factors view the inflationary mechanism from the supply side, and in consequence an inflationary mechanism compatible with these theories is often termed sellers' inflation. These theories have been regarded as particularly relevant to situations typified by excess supply of labour or commodities and, simultaneously, by rising wages or prices. Such theories, resting on the so-called cost-push hypothesis, presuppose imperfect competition, since it is only under imperfectly competitive conditions that sellers can be supposed to be able to shift cost increases freely to prices.[2] On the other hand, changes in the cost level can be assumed to result in shifts in the market supply curve of commodities, and in this sense cost-push theories are also relevant under conditions of perfect competition.[3] Analogously, in considering factor markets, theories according to which changes in commodity prices lead directly to changes in factor prices may be called cost-push theories.

It is quite generally agreed today that neither an excess demand theory nor a cost-push theory is sufficient in itself to explain the process of inflation. Attempts have therefore been made to combine the two points of view. In recent investigations efforts have in fact been made to construct models permitting the emergence of inflationary processes on the basis of both demand and cost factors.[4]

of excess demand) as traditional analysis does; see B. Hansen A Study in the Theory of Inflation, London 1951, pp. 3—13. It should further be stated that the traditional excess demand hypothesis is symmetric, in the sense that prices are supposed to rise when there is excess demand and to fall when there is excess supply. Paunio's and Hansen's models are also symmetric. The Keynesian theory, by contrast, assumes that output and employment will decline in the case of excess supply.

2. Samuelson and Solow consider it impossible to explain inflation on the basis of the cost-push approach unless the assumption of perfect competition is at least partly abandoned. The neo-classical model was a perfect competition model, according to which prices and wages were bound to fall when there was excess capacity in the sense that the marginal costs of firms were smaller than the respective prices. It is impossible to explain why prices and wages may rise even before full employment and full capacity utilization have been reached unless elements of imperfect competition are introduced into the model. The Keynesian "*General Theory*" model, in which prices and wages were inflexible in a state of equilibrium characterized by the presence of unemployment, necessarily rested on certain underlying assumptions implying imperfect competition. See P. A. Samuelson & R. M. Solow "Analytical Aspects of Anti-Inflation Policy" in *The Collected Scientific Papers of Paul A. Samuelson*, II, The M.I.T. Press 1966, pp. 1339—1340.

3. A difficult problem of identification is, however, encountered here, because a shift in the supply curve leads to the emergence of positive or negative excess demand.

4. Attempts to combine the cost-push and demand-pull analysis have been made, for example, in the following: J. J. Paunio A Study in the Theory of Open Inflation, Helsinki 1961, and J. D. Pitchford A Study of Cost and Demand Inflation, Amsterdam 1963.

Numerous empirical studies have been based on such theories. The results arrived at have, however, the following common feature: they have led to the pessimistic view that price stability and full employment are mutually incompatible policy goals. In other words, if the price level is stabilized, a degree of unemployment must necessarily be tolerated. This conclusion has been reached mainly because the empirical studies concerned have been in the nature of partial analysis. The market demand and supply conditions have been dealt with as exogenous elements, and thus the simultaneous occurrence of unemployment and price increases has affected the results.

On the other hand, shifts in demand and supply curves occur continually, and since adjustment requires time, it may be impossible to observe equilibria.[5] The present study in fact starts from the assumption that the unit period is not long enough for adjustment, with the result that the system will proceed from one state of disequilibrium to another. A given set of values of the endogenous variables corresponds to each of these disequilibria. An effort will be made to derive the hypotheses in such a way that the variables describing the behaviour of the labour market will receive an endogenous role, so that both the movements in the price level and those in employment can be derived from changes in the exogenous variables included in the system. Simultaneous occurrence of price increases and unemployment will then imply no constraints on the empirical interdependence of these variables, and thus it is possible to explore whether a combination of the exogenous variables can be found which allows the attainment of price stability and full employment as simultaneous policy goals.

The purpose of the present study is thus to construct an inflation model permitting the occurrence of demand and supply disequilibria. By means of an empirical version of this model an attempt will be made to investigate not only the dynamic time path of the inflationary process but also the economic policy implications of the model, the main emphasis being on an analysis of the exogenous mechanism equilibrating demand and supply in the labour market.

5. Cf. T. Helelä "Palkkarakenteen muutoksista", *KAK* No. 2 1966, p. 136.

2. BACKGROUND OF THE STUDY

2.1. THE PROBLEM IN HISTORICAL PERSPECTIVE

The economic environment of the classical economists was characterized by a slowly progressing secular inflation. A very simple assumption was framed by them to account for the observed movements in the price level: the price level was supposed to bear a constant ratio to the quantity of money. This quantitity theory of money incorporated the view that (at any given price level) a given quantity of money represented a given demand potential. Provided that demand and supply were in equilibrium in the initial situation, any increase in the quantity of money was considered to mean an increase in the demand potential or to result in monetary excess demand. A rise in the price level was regarded as necessary to regain equilibrium.

The picture provided by this unsophisticated version of the quantity theory of the workings of the price mechanism was deficient, and it was only certain neo-classical economists, including WALRAS, MARSHALL and FISHER, who succeeded in developing it into a serviceable theory of the determination of the price level in terms of changes in the quantity of money.

The point of departure in the variant of quantity theory suggested by representatives of the neo-classical school was the view that real output, real inputs and the relative prices of outputs and inputs were determined by a system of simultaneous equations which was independent of the absolute level of prices. The absolute price level was indeterminate, as a result of the »relative homogeneity» of these market equations. To fix an absolute »scale» for the system, neutral money was introduced into the picture. The demand for money was assumed to increase n-fold as prices multiplied n-fold. Hence, as soon as the total quantity of money was fixed, the absolute price level was also fixed. When a change took place in the quantity of money, the level of absolute prices changed in exactly the same proportion.[1] Thus,

1. In their analyses based on the quantity theory, neo-classical economists applied the so-called equation of exchange, $MV = pT$, where M = the quantity of money, V = the velocity of money, p = the price level and T = the quantity of transactions. Both the velocity of money and the quantity of transactions were assumed to be constant. From this the neo-classicists concluded that the elasticity of the price level with respect to the quantity of money was equal to unity.

changes in the quantity of money did not affect relative prices or real magnitudes at all.[2]

The quantity theory was based on the underlying assumption that the velocity of circulation of money remained constant.[3] The sharp changes in the velocity observed particularly in 1930 discredited the quantity theory to some extent, however, even though explanations based on it were still resorted to in practice.[4] The most important contribution to the critical discussion of the quantity theory has been made by PATINKIN, who tried to render the theory concerning the determination of the absolute price level more realistic.[5] According to Patinkin, the absolute price level can be rendered determinate without introducing a separate quantity equation, by including the »real cash holdings» of economic units in the demand equations.

In the dynamic system of the neo-classical economists changes in individual prices were dependent on the quantity of excess demand. WICKSELL may have been the first to apply this theory to aggregate-level relationships. In his model, however, the total amount of monetary excess demand found an outlet in a rise of the price level.[6]

It seems legitimate to maintain that Wicksell's analysis furnished a basis for all the later studies on the theory of inflation conducted by representatives of the Stockholm school. In the theories of inflation suggested by them the demand and supply conditions in the labour market also had a part to play.[7] According to these theories, excess demand in the commodity market occasioned pressures in the labour market, too, and results in increases in wages as well as in commodity prices.[8]

It should be pointed out in this context that the difference between the

2. P. A. SAMUELSON & R. M. SOLOW "Analytical Aspects of Anti-Inflation Policy" in *The Collected Scientific Papers of Paul A. Samuelson*, II, The M. I. T. Press 1966, pp. 1336—1337.

3. In the form given to it by neo-classical economists; cf. footnote 1.

4. M. BRONFENBRENNER & F. D. HOLZMAN "Survey of Inflation Theory", *Am. Econ. Rev.*, Sept. 1963, p. 600.

5. D. PATINKIN Money, Interest and Prices, London 1956.

6. K. WICKSELL Geldzins und Güterpreise, Jena 1898 (an English translation, Interest and Prices, New York 1962).

7. See B. HANSEN A Study in the Theory of Inflation, London 1951, p. 18.

8. Cf. the interpretation suggested in L. R. KLEIN, R. J. BALL, A. HAZLEWOOD & P. VANDOME An Econometric Model of the United Kingdom, Oxford 1961, p 112. The authors maintain that, according to these theories, excess demand in the commodity market causes pressures in the labour market that find an outlet in price increases. These, in turn, lead to price increases in the commodity market. Thus, on this interpretation, excess demand in the commodity market does not directly lead to price increases.

quantity theory and the theories of inflation based on changes in monetary excess demand is not, in principle, very great. According to the definition presented by BENT HANSEN, monetary excess market demand = the excess supply of money.[9]

In his »*General Theory*» KEYNES also stressed the importance of the total monetary demand as a determinant of changes in the price level. According to his theory, an increase in total demand opened up an »inflationary gap», and a rise in the price level was necessary for the gap to be closed. The most noticeable difference between the Keynesian theory and former theories was, however, that Keynes assumed the behaviour of prices to be asymmetric — prices were flexible only upwards in his model; and, rather than being reflected in price cuts, a decline in demand in monetary terms below the full employment level resulted in a fall of output and employment. Although there was much resemblance between the Keynesian theory of inflation and the quantity theory of the neo-classical school after the attainment of full employment, the two differed decisively below the full employment level.[10]

In the inflation theories discussed above the main emphasis was distinctly on the commodity market. This obviously explains why the development of the theory of wages took place entirely independently of the theory of inflation, concerned with the determination of the price level. It would seem in fact that the development of wage theory was influenced more by the development of the institutional structure of the labour market. The changes that have occurred in the institutional structure are reflected quite clearly in the following theories, for example: the subsistence minimum theory of wages, the wage-fund theory, the bargaining power theory and the purchasing power theory of wages.[11]

It should be pointed out, on the other hand that, as a matter of fact, the neo-classical model also involved wages. In the system discussed by the neo-classical writers, prices and wages were determined simultaneously, although the ratio between the price and wage levels remained unchanged when changes took place in the quantity of money; in other words, prices and wages changed in the same proportion, and thus there was no need for a separate wage theory.

For some reason or other, however, it became customary to consider one particular equilibrium equation of the neo-classical model as a wage theory,

9. B. HANSEN op. cit., pp. 4—5.

10. J. M. KEYNES The General Theory of Employment, Interest and Money, New York 1936.

11. For these theories, see P. A. SAMUELSON "Economic Theory of Wages" in *The Collected Scientific Papers of Paul A. Samuelson*, II, The M.I.T. Press 1966.

viz., the equation according to which the real wage equals the marginal productivity of labour in equilibrium (under perfect competition). This so-called marginal productivity theory of wages set the pattern for the theoretical thought regarding wages for a long time. It has, however, generally been regarded as one-sided, in the sense that the situation is viewed from the demand side alone, neglecting the conditions on the supply side of the factors of production.[12]

In his *General Theory* Keynes considered wages as an exogenous, given variable. The analysis in his book *How to Pay for the War*[13] can, however, be seen as the beginning of the later endeavours to explore how inflation actually works.[14] According to Keynes, prices react to excess demand, and wages adjust to the altered prices. Thus, his theory of inflation was a demand-pull theory of prices and a cost-push theory of wages. After this it became customary to analyze inflation along the lines blazed by Keynes, and a majority of the inflation theorists who sought to explain price movements considered it appropriate to try and explain changes in the wage level simultaneously.[15]

2.2. THE STUDY OF INFLATION AFTER THE SECOND WORLD WAR

Since there is no intention here to give a complete account of the historical development of the study of inflation, only the features relevant to the model to be constructed in this study will be dealt with. Moreover, attention will be focused mainly on empirical investigation, except where theoretical analysis has, in a sense, paved the way for empirical studies. If matters are drastically simplified, the following hypotheses can be asserted to have occupied a pivotal position in post-war studies of inflation, both theoretical and empirical.

	A. Price level	B. Wage level
1.	$\Delta p = F_1(Y^d - Y^s),\ F_1' > 0$	$\Delta w = F_3(N^d - N^s),\ F_3' > 0$
2.	$\Delta p = F_2(\Delta w),\ F_2' > 0$	$\Delta w = F_4(\Delta p),\ F_4' > 0$
3.	$\Delta p = \overline{\Delta p}$	$\Delta w = \overline{\Delta w}$

12. See, e.g., J. T. Dunlop "The Task of Contemporary Wage Theory" in *The Theory of Wage Determination*, ed. John T. Dunlop, London—New York 1957.

13. J. M. Keynes How to Pay for the War, London 1940, pp. 57—74.

14. This view was advanced by J. D. Pitchford A Study of Cost and Demand Inflation, Amsterdam 1963, p. 19.

15. See, e.g., T. C. Koopmans "The Dynamics of Inflation", *Rev. Econ. Stat.*, Feb. 1942.

where p = the price level (Δp = change in the price level), w = the wage level, Y^d = the demand for commodities, Y^s = the supply of commodities, N^d = the demand for labour and N^s = the supply of labour.

To employ the Keynesian terminology, »induced» price and wage changes or »flexible» prices and wages are concerned in Hypotheses A.1 and B.1.[16] According to Hypotheses A.2 and 3 and B.2 and 3, price and wage changes are »autonomous» or prices and wages »spontaneous». Hypotheses A.3 and B.3 relate to situations where price and wage changes are wholly exogenous. In the case of Hypotheses A.1 and B.1 excess demand inflation and, in the case of Hypotheses A.2 and B.2, cost-push inflation can be spoken of.

Most of the post-war studies of inflation amount to various combinations of the above six hypotheses. The properties of each model depend decisively on the way in which these hypotheses are combined. In 1950 DUESENBERRY proposed a model in which prices were determined by a particular combination of Hypotheses A.1 and A.2, whereas wages were determined simply by B.2.[17] HOLZMAN suggested the same year an inflation theory in which prices behaved according to A.2 and wages according to B.2.[18] In Duesenberry's theory equilibrium was reached in the commodity market (by virtue of A.1) as soon as the rise in prices came to an end, and the rise in wages ended (by virtue of B.2) simultaneously. This did not imply, however, that the labour market was necessarily in equilibrium (since B.1 was not involved in the model). Holzman's model permits the occurrence of disequilibria both in the commodity and in the labour market (both A.1 and B.1 were absent), the price and wage changes being exclusively dependent on each other. In Bent Hansen's model, by contrast, when price-wage equilibrium prevails, both the commodity market and the labour market may be in equilibrium (the model consists of A.1 and B.1).[19] Empirical investigation has, however, shown convincingly enough the relevance of Hypotheses A.2 and B.2, too, and thus a position of preference cannot be given to Bent Hansen's model solely because of its equilibrium properties.[20] Hypotheses 1 and 2 have been combined both

16. See J. M. KEYNES A Treatise on Money, London 1930, Chapter 11. See also B. HANSEN op. cit. pp. 14—18 and J. J. PAUNIO op. cit. pp. 59—60. Paunio makes a distinction between flexible and spontaneous (autonomous) prices.

17. J. S. DUESENBERRY "The Mechanics of Inflation", *Rev. Econ. Stat.*, May 1950.

18. F. HOLZMAN "Income Determination in Open Inflation", *Rev. Econ. Stat.*, May 1950.

19. B. HANSEN op. cit.

20. Cf. PITCHFORD A Study of Cost and Demand Inflation, Amsterdam 1963.

in the explanatory equation for the price level and in that for the wage level only in PITCHFORD's studies on the theory of inflation.[21]

Numerous empirical studies of inflation have been published during the past decade. Only a few investigations that fit in well with the above classification and are (in the present writer's opinion) important for the quantitative study of inflation, will be considered here. A. W. PHILLIPS's investigation, resting on Hypothesis B.1, has probably attracted more attention than any other comparable empirical study.[22] It can be regarded mainly as an empirical application of Bent Hansen's labour market sector model. R. LIPSEY's study followed lines similar to those adopted by Phillips, except in that his model was linear in the parameters and was based on a combination of Hypotheses B.1 and B.2.[23] The study carried out by DICKS-MIREAUX and Dow rested on a combination of the same hypotheses.[24] The two studies differed mainly in the construction of the variables and the lag patterns of the model. A detailed consideration of these models does not, however, seem to be called for at this point.

The best-known attempts to construct econometric models explaining the movements in price and wage levels simultaneously include the studies carried

21. Pitchford starts from the assumption that certain prices behave in accordance with A.1, while others behave in accordance with A.2. Likewise, the determination of some wages obey B.1, whereas others are determined as in B.2. In other words, some prices and wages are determined under conditions of perfect competition, the rest being determined under conditions of imperfect competition. Hence, when all prices and wages are considered simultaneously, their behaviour can be explained by combinations of A.1 and A.2 and by combinations of B.1 and B.2 respectively. As regards the determination of wages Pitchford states, it is true, that if "the cost formula is varied to take account of excess demand or supply the profit margin has to be manipulated in order to take advantage of the market power of the firm"; and with regard to wages he writes: "A mixture of cost influences would operate if unions varied their real wage claim in response to market forces, taking advantage of excess demand to press for higher (real) wages, and reducing claims when labor was in excess supply." See PITCHFORD op. cit. pp. 17 and 18. The present writer has interpreted these assertions to imply that, as Pitchford sees it, his model is also relevant when all prices and wages are determined under imperfectly competitive conditions but respond, nevertheless, to changes in demand conditions. The manipulation of the profit or "mark-up" margins presupposes, however, an ability of entrepreneurs to influence prices, and this is of course the case only in imperfectly competitive markets.

22. A. W. PHILLIPS "The Relation between Unemployment and the Rate of Change of Money Wages Rates in the United Kingdom, 1861—1957", *Economica*, Nov. 1958.

23. R. LIPSEY "The Relation between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1862—1957: A Further Analysis", *Economica*, Feb. 1960.

24. L. A. DICKS-MIREAUX & J. C. R. Dow "The Determinants of Wage Inflation", *Oxf. Econ. Papers*, Oct. 1961.

out by Dicks-Mireaux and the team of KLEIN and BALL.[25] In both cases the price equation rests on Hypothesis A.2 and the wage equation on a combination of Hypotheses B.1 and B.2.

The present writer knows only a single econometric study from the post-war era in which an attempt was made to apply a hypothesis based on the quantity theory of money, viz., HARBERGER's study of inflation in Chile.[26] The school of the so-called new quantity theory of money, grouped around MILTON FRIEDMAN, has provided a stimulus for certain empirical studies of inflation resting on a quantity-of-money approach, it is true, but the principal purpose of these investigations has been to build an explanatory model for hyper-inflation, rather than for creeping inflation.[27] The present study deals mainly with the latter phenomenon.

25. L. A. DICKS-MIREAUX "The Interrelationship between Cost and Price Changes, 1946—1959: A Study of Inflation in Post-War Britain", *Oxf. Econ. Papers*, Oct. 1961; and L. R. KLEIN & R. J. BALL "Some Econometrics of the Determination of Absolute Prices and Wages", *Econ. Jour.*, Sept. 1959.

26. A. C. HARBERGER "The Dynamics of Inflation in Chile" in *Measurement in Economics*, ed. C. F. Christ et al., Stanford 1963.

27. See, e.g., P. CAGAN "The Monetary Dynamics of Hyperinflation" in *Studies in the Quantity Theory of Money*, ed. M. Friedman, Chicago 1956.

3. THE PURPOSE AND BASIC MODEL OF THE PRESENT STUDY

3.1. CHOICE OF THE FRAME OF REFERENCE

The available model universe relevant to the present study may be classified as follows: equilibrium models, adjustment models and disequilibrium models.

I. Equilibrium models

(3.1) $N = f_1(w)$, demand for labour

(3.2) $N = f_2(w)$, supply of labour

(3.3) $Y = f_3(p)$, demand for commodities

(3.4) $Y = f_4(p)$, supply of commodities

The system consisting of equations (3.1) to (3.4) is considered here to be part of some more comprehensive system, where the number of unknowns equals the number of equations. If a solution can be found for the system, it can be called an equilibrium solution, the values for the price level and wage level involved in it being those at which supply equals demand both in the commodity and in the labour markets. Models where the equality of demand and supply is explicitly ensured through the conditions,

(3.5) $f_1(w) = f_2(w)$

(3.6) $f_3(p) = f_4(p)$

also belong to this category.

II. Adjustment models

(3.7) $N^d = f_5(w)$, demand for labour

(3.8) $N^s = f_6(w)$, supply of labour

(3.9) $Y^d = f_7(p)$, demand for commodities

(3.10) $Y^s = f_8(p)$, supply of commodities

(3.11) $\Delta w = f_9(N^d - N^s)$, wage level adjustment equation

(3.12) $\Delta p = f_{10}(Y^d - Y^s)$, price level adjustment equation

Traditional theory supposes that

$$(3.13)\quad f_9(0) = 0,\ f_{10}(0) = 0.$$

The condition (3.13) means that, in stationary equilibrium, demand equals supply in the labour and commodity markets when $\Delta\, w = \Delta\, p = 0$.

The theoretical models considered in the preceding chapter, except those based on the quantity theory, were adjustment models. A vast majority of the empirical applications with which the present writer is familiar are also based on the adjustment model presented here, and on equation (3.11) in particular.[1] These empirical studies, where the wage equation incorporates the excess demand hypothesis — the inequality between the demand and supply of labour being measured in most cases by means of unemployment or some other magnitude derived from it — have been criticized on the ground that unemployment has been dealt with as an exogenous variable in these models.[2] As already stated in the Introduction, such partial analyses have suggested the conclusion that full employment and the stability of the price and wage levels are mutually incompatible goals of economic policy.

The adjustment model has also been criticized on account of the assumption of perfect competition implicit in it.[3]

As was stated in the Introduction, an assumption basic to this study is that the unit period is not long enough for complete adjustment, so that the system will move from one state of disequilibrium to another. A model based on this assumption can be termed a disequilibrium model and represented formally as follows.

III. Disequilibrium models:

$$(3.14)\quad N^d = f_{11}(w), \text{ demand for labour}$$

$$(3.15)\quad N^s = f_{12}(w), \text{ supply of labour}$$

$$(3.16)\quad Y^d = f_{13}(p), \text{ demand for commodities}$$

1. Implications of these applications will be discussed in Chapter 6.

2. Edvin Kuh, for example, states that "wage determination equations require a complete econometric model for two basic and obvious reasons. Clearly, wages and prices are jointly dependent variables which strongly affect each other. Since employment, too, is an endogenous variable, it should in principle not be treated as an independent variable in an ordinary least squares regression". See E. Kuh "A Productivity Theory of Wage Levels — An Alternative to the Phillips Curve", *Rev. Econ. Stud.*, Oct. 1967, p 333.

3. Arrow, for example, writes: "It is not explained whose decision it is to change prices in accordance with this equation [refers to equation A.2 in Section 2 of Chapter 2]. Each individual participant in the economy is supposed to take prices as given and determine his choices as to purchases and sales accordingly; there is no one left over whose job it is to make a decision on price." See K. Arrow "Toward a Theory of Price Adjustment" in *The Allocation of Economic Resources*, Calif. 1959.

(3.17) $Y^s = f_{14}(p)$, supply of commodities

(3.18) $w = f_{15}(N^d - N^s)$, wage-level determination

(3.19) $p = f_{16}(Y^d - Y^s)$, price-level determination

The model is completely static, and the solution based on the equilibrium values of the variables is typified by an inequality between demand and supply both in the commodity and in the labour market.[4] The possibility of an equilibrium solution implying equality of demand and supply is not, however, excluded.

An analysis based on the equilibrium values does not, however, reveal anything about the dynamics of the inflationary mechanism. To get to grips with the dynamic properties of the model, the model must be »dynamized». This can take place in a variety of ways. The most usual way seems to be to express the hypotheses in dynamic terms. Of the models dealt with above, the adjustment model is dynamic in itself, since the basic assumptions underlying it are formulated in dynamic terms. On the other hand, the only way of dynamizing the equilibrium and disequilibrium models is to make the unit period short enough for the »natural» lags between the variables to manifest themselves.

3.2. THE PURPOSE OF THE STUDY

The object of this study is, first, to construct a theoretical disequilibrium model, with the chief emphasis on the description and explanation of the inflationary process. The hypotheses incorporated in the model will then be reconsidered, equation by equation, and reformulated so as to be suitable for

4. Edvin Kuh's theoretical consideration of wages led him to a model which can be assigned to this category. He states that unemployment has "an important influence on the bargaining position of labour and management and the ultimate equilibrium *level* that will be achieved". In the empirical part of his study Kuh returned, however, to the adjustment model. See KUH op. cit. p. 339.

An analysis based on the equilibrium values of the variables, however, is apparently not acceptable to all wage theorists. J. D. Sargan ended up with an equation where the wage *level* was dependent on unemployment. (See J. D. SARGAN "Wages and Prices in the United Kingdom: A Study in Econometric Methodology" in *Econometric Analysis for National Economic Planning*, London 1964.) In the discussion that followed, R. J. Ball stated: "It seems to me that Sargan's model confuses the characteristics of the equilibrium market structure and the dynamic adjustment function, as they are usually interpreted. He relates the equilibrium *level* of real wages to the *level* of unemployment, where conventional economic theory relates unemployment to a rate of change."

empirical analysis. At the same time an attempt will be made to discover under what conditions the assumption of a permanent disequilibrium of demand and supply is compatible with the traditional theory of market behaviour.

Following this the model will be subjected to empirical investigation. Initially the relationships will be analyzed by employing the ordinary least squares method, and only when satisfactory structures have been discovered will the model be estimated simultaneously. The empirical study relates to the Finnish economy. The data consists of quarterly observations for the years 1957 to 1966.

The centre of emphasis in the model lies in the labour market. This means, in the first place, that an endogenous role is assigned to the labour market in the model; in other words, the disequilibrium of demand and supply, or excess demand, in the labour market has to be endogenized. In consequence, at least a demand for labour equation must be included in the final model. The supply of labour is often regarded as a given exogenous variable. Here, however, it was found appropriate to seek to explain both the demand for and the supply of labour separately. Hence, the construction of demand and supply functions of labour suitable for empirical analysis was set as a goal.

For the sake of consistency, the model should also include both a demand and a supply equation for the commodity market — in so far as the hypotheses discussed above are chosen as a point of departure. Separate observations are not, however, available on these variables; only the output of commodities is observable, and it reflects the behaviour of the decision-makers on both the demand and the supply side. Therefore, the end of the »chain» in the commodity market is left open, in the sense that excess demand in the commodity market is dealt with as an exogenous variable. The discovery of an operational indicator for excess demand in the commodity market was, however, adopted as one of the goals of the study.

Since the model will include separate demand and supply equations for labour, it will also be possible to explore the causal relations between prices and wages and between the demand for and supply of labour in both directions. The available empirical studies suggest, in fact, that the demand situation in the labour market has some effect on the determination of wages. But do the price and wage levels also influence the labour market demand and supply situation and, via this, unemployment? The objectives of this study include an analysis of this question.[5]

5. The following passage, where E. Kuh discusses the possibility that the causal relationship in question may be weak, should be quoted in this context. "In discussion of the Phillips Curve, it is usual to treat unemployment as both predetermined and the main

When the model is endogenized to the greatest extent possible, the factors ultimately responsible for the inflationary process can also be considered, since these will then constitute the exogenous variables included in the model. Such endogenous variables as the price and wage levels and employment are interdependent in the short run, but in the long run they are all dependent on a set of exogenous variables.

The basic model chosen for the study was stated to be static. Yet it is not enough to analyze the static structure of the model; the way in which the model actually works can be discovered only by analyzing its dynamic structure. Hence, the goal in this context is to explore, on the basis of the empirical model, the dynamic properties of the model and the nature of the time path implied by it. At this point, a quotation from EDVIN KUH's excellent article is again called for: »Suppose that the simultaneous difference equations in wages and prices are linear. If the largest root of the homogeneous system is less than unity in absolute value, the system will be damped. Even though wages determine prices and prices determine wages in the short run, *neither determines the absolute level of prices or wages* in the long run. It will be the exogenous variables, operating through the parameters of the entire system (i.e., the steady state solution of the reduced form) that will causally determine wage and price levels. This elementary point appears to be insufficiently recognized in the literature on this subject.[6]

Finally, certain economic and economic-policy implications of the model will be discussed on the basis of the dynamic analysis of it.

policy instrument, and wages and prices as endogenous variables. This procedure is not generally legitimate since wages, prices and unemployment are endogenously determined in a complete macro model. However, as many macro models are now structured, unemployment is determined in the real sector which, in turn, is only weakly affected by the absolute level of prices. Thus a block triangular coefficient set exists, with the causal direction running from unemployment to wage rates, but not the other way during the current period. Goldberger has found that the Klein—Goldberger annual model of the U.S. economy is characterized by an even stronger isolation of prices and wages from the real sector, of the sort associated with block diagonality. Even though the Klein—Goldberger model would now be thought rudimentary, this possibility should still be on the research agenda.

Triangular or diagonal coefficient matrices are enough justification for treating unemployment as predetermined in the Phillips sort of analysis, but consistent estimation requires that the error covariance matrices be diagonal in addition. It is hard to form strong prior beliefs about this error term property, so that these covariances should be estimated." See E. KUH op. cit. p. 343.

6. E. KUH op. cit. p. 342.

3.3. THE BASIC MODEL

Let us consider now the possibility of constructing a theoretical model with a built-in mechanism capable of producing solutions which presuppose inequality of demand and supply. Even though in this study the main emphasis will ultimately be on the labour market, at this stage the commodity market is still considered as an endogenous element of the model.

Keynes's *General Theory* model belongs mainly to the category of »equilibrium models». His model also permits a solution characterized by disequilibrium of demand and supply in the labour market, since equilibrium may be attainable only at economically impossible values of the variables, e.g., at a negative rate of interest.[7] Nevertheless, the model does not involve any mechanism necessitating the occurrence of disequilibrium.

In the case of adjustment models, too, the properties of stationary equilibrium may be affected by introducing certain additional requirements. If the conditions (3.13), stating that $f_9(0) = 0$, $f_{10}(0) = 0$, are replaced by

$$(3.20) \qquad f_9(0) \neq 0, \quad f_{10}(0) \neq 0,$$

inequality of demand and supply is rendered compatible with dynamic equilibrium. Nevertheless, despite the additional conditions, the model does not include any mechanism forcing the variables to assume values presupposing the inequality of demand and supply. On the other hand, when these restrictions are imposed on the adjustment functions, the possibility of stationary solutions presupposing the equality of demand and supply is excluded.

By contrast, if »disequilibrium models» are chosen as the point of departure, a model can be constructed where a built-in disequilibrium mechanism permits including the possible inequality of demand and supply as an explicit element in the model and in such a way that it directly affects the equilibrium values of the other variables. When the problem is approached by employing disequilibrium models, one question to be considered is the following: How are the realized values of output and employment determined when there is an inequality of demand and supply in the markets?

The following restrictions will be imposed on the model to be built: it

7. L. R. Klein op. cit. pp. 84—87 and 265—267. Alternative interpretations of the Keynesian underemployment equilibrium have also been suggested, most of them resting either on a postulated rigidity of the wage level or on a perfectly interest-inelastic liquidity preference function. See W. L. Smith "A Graphical Exposition of the Complete Keynesian System" in *Readings in Macroeconomics*, ed. M. G. Mueller, Calif. 1965, pp. 37—47. See also R. G. D. Allen Macro-Economic Theory, New York 1968, pp. 130—131.

will be a short-run model and a model of a closed economy.[8] Both the demand for and the supply of labour will simply be assumed to depend on the relative prices, and thus the labour market equations can be written

$$(3.21) \qquad N^d = N^d\left(\frac{w}{p}\right)$$

$$(3.22) \qquad N^s = N^s\left(\frac{w}{p}\right)$$

where N^d = the demand for labour, N^s = the supply of labour, w = the wage level and p = the price level.

If the right sides of (3.21) and (3.22) were equated, the model could be solved for the relative prices or, provided that one or the other of these were known, for the absolute wage and price levels. Equality of the right sides of these equations would, however, presuppose an equality between the demand for and supply of labour. The following equation, by contrast, which relates realized employment, the demand for labour and the supply of labour to one another, does not include such an assumption:

$$(3.23) \qquad N = {}_{min}(N^d, N^s)$$

or, in words, realized employment equals either the demand for or the supply of labour, depending on whichever is the smaller.

The commodity market demand function can be written in accordance with the Keynesian model

$$(3.24) \qquad Y^d = C(Y) + I(Y, r)$$

where Y^d = the volume of the demand for commodities, C = the volume of consumption demand, I = the volume of investment demand, Y = realized output and r = the rate of interest (which is assumed to be kept constant through monetary policies). When an attempt is made to construct a supply equation for the commodity market, the following technical difficulty is, however, encountered: the supply function is subject to the restrictions implied by the production function. It is difficult to include both functions in the same model, since there is the danger that the model as a whole becomes over-determined, in the sense that there will be more equations

8. The initial stimulus for the construction of this model was provided by an unpublished version of R. M. Solow & J. E. Stiglitz's article on "Output, Employment and Wages in the Short Run", Massachusetts Institute of Technology. It helped the present writer to form a picture of the technical difficulties associated with the construction of the model.

than variables. It is therefore necessary to incorporate both functions in a single equation that depicts the situation from the production and supply aspects at once. By applying the technique employed by SOLOW and STIGLITZ, the supply function may be constructed as follows.

Introduce, for the moment, the following short-run production function:[9]

$$(3.25) \qquad Y = F(N), F' > 0.$$

The total supply of commodities, Y^s, is the supply at which the price level equals marginal cost (or, in imperfectly competitive markets, a multiple of marginal cost); and since labour is assumed to be the only variable factor of production, Y^s represents that quantity of supply at which the marginal product, $F'(N)$, equals the real wage rate. The supply function for the commodity market can then be written

$$(3.26) \qquad Y^s = F\left[F'^{-1}\left(\frac{w}{p}\right)\right] = Y^s\left(\frac{w}{p}\right)$$

where F'^{-1} is the inverse function of F'. The information inherent in the production function (3.25) has thus been utilized in the construction of the supply equation (3.26), and the existence of (3.25) can be forgotten.

It should be observed at this point that the information contained in the demand for labour function (3.21) can be given an interpretation analogous to the one given to the commodity market supply function (3.26). In other words, N^d may be taken to represent that level of the demand for labour at which the marginal product of labour equals the real wage rate, the information inherent in the production function being involved only implicitly in the demand for labour function.

Realized output can be defined now in a way analogous to the definition of realized employment:

$$(3.27) \qquad Y = {}_{min}(Y^d, Y^s)$$

or, in words, realized output equals the smaller of the variables Y^d and Y^s.

Six equations have been constructed so far, whereas there are eight variables. The model can be closed by including in it two behaviour equations, one for prices and the other for wages. Solow and Stiglitz assumed changes in prices and wages to depend not only on each other but also on the difference between demand and supply in the commodity and labour markets

9. R. M. SOLOW & J. E. STIGLITZ op. cit. p. 4.

respectively.[10] Their price and wage equations were thus of the following form:

(3.28) $$\Delta p = f_1(Y^d/Y^s) + f_2(\Delta w)$$

(3.29) $$\Delta w = f_3(N^d/N^s) + f_4(\Delta p)$$

If there were any reason to suppose that price and wage changes would clear the market, i.e., that demand and supply are in equilibrium both in the commodity and in the labour market when the rise in prices and wages comes to an end, the following assumptions should be made concerning the behaviour of f_1 and f_3 (postulating, of course, that $f_2(\Delta w) = f_4(\Delta p) = 0$):

(3.30) $$f_1(1) = 0$$

(3.31) $$f_3(1) = 0.$$

On the other hand, if disequilibrium of demand and supply were considered to be characteristic of stationary equilibrium, (3.30) and (3.31) should respectively be replaced by

(3.32) $$f_1(1) \neq 0$$

(3.33) $$f_3(1) \neq 0$$

or, on the further assumption that frictional unemployment is characteristic of stationary equilibrium and that prices start to rise even before the productive capacity is fully utilized, by

(3.34) $$f_1(1) > 0$$

(3.35) $$f_3(1) > 0.$$

It might be of interest to investigate the dynamic properties of a model involving price and wage adjustment equations similar respectively to (3.28) and (3.29). As was stated in Section 3.2, however, in this study such an analysis will be carried out only by means of the empirical model to be derived. The objectives of the present study also necessitate replacing equations (3.28) and (3.29) by other behavioural equations, compatible with a disequilibrium model rather than with an adjustment model. These new equations will be as follows:[11]

10. R. M. Solow & J. E. Stiglitz op. cit. pp. 11—12.

11. The next chapter includes a discussion of the theoretical justification of these equations.

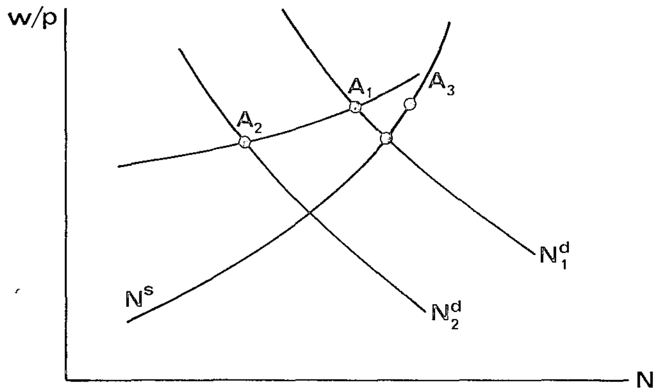

Figure 1.

(3.36) $$p = f\,(Y^d - Y^s,\ w)$$

(3.37) $$w = g\,(N^d - N^s,\ p).$$

The implications of these equations are analyzed below by means of Figure 1.[12]

The demand for and supply of labour are represented in the figure as functions of the real wage. Let us assume that the point A_1, at which unemployment is A_3—A_1, represents stationary equilibrium. Now, if the demand for labour curve shifts downwards to the position N_2^d, the new point of equilibrium will not, however, be in the vicinity of the intersection of the new demand curve and the curve N^s but, instead, at A_2. The curve through the points A_1 and A_2 is the graph of the wage equation (3.37). It quite obviously has the properties of a Keynesian short-run supply of labour function provided that N^d and N^s can be interpreted as long-run curves. Supply is almost perfectly elastic below the full-employment level, which is represented by the point A_1 when frictional unemployment is A_3—A_1. To the left of this point, the supply of labour grows increasingly elastic with respect to the real wage.

An analogous interpretation applies to the price equation. The price and wage equations may be characterized in this context as the "monetary" supply equations for the commodity and labour markets respectively. The pieces can be put together now, to obtain the following disequilibrium model:

12. Cf. T. M. Brown "A Forecast Determination of National Product, Employment and Price Level in Canada, from an Econometric Model" in *Models of Income Determination*, NBER Vol. 28, Princeton 1964.

$$N^d = N^d\left(\frac{w}{p}\right) \quad (3.21)$$

$$N^s = N^s\left(\frac{w}{p}\right) \quad (3.22)$$

$$N = {}_{min}(N^d, N^s) \quad (3.23)$$

$$Y^d = C(Y) + I(Y, r) \quad (3.24)$$

$$Y^s = Y^s\left(\frac{w}{p}\right) \quad (3.26)$$

$$Y = {}_{min}(Y^d, Y^s) \quad (3.27)$$

$$p = f(Y^d - Y^s, w) \quad (3.36)$$

$$w = g(N^d - N^s, p). \quad (3.37)$$

The number of equations in the model equals the number of endogenous variables, and thus the model is according to this criterion completely determinate. It is possible for the equations of the model to be satisfied by values at which demand and supply will be unequal both in the commodity and in the labour market. On the other hand, demand may equal supply in one market, without implying anything about equilibrium in the other. And, finally, demand and supply may be unequal in both markets simultaneously.

The model is entirely static, however, and provides no opportunity for dynamic analysis. On the other hand, the causal chains connecting the different variables can be considered on the basis of it. Construction of an empirical model in which the "monetary" variables (prices and wages) and the real variables (the demand and supply volumes) are connected by causal chains running in both directions was set as an objective of this study in the first section of this chapter. In this respect the formal model constructed above corresponds to the goals of the study and can be utilized as a frame of reference in building the empirical model aimed at. The causal chain connecting the real with the "monetary" variables runs through equations (3.36) and (3.37), whereas the chain in the reverse direction runs through equations (3.21), (3.22) and (3.26).

4. DERIVATION OF HYPOTHESES

4.1. DETERMINATION OF THE PRICE LEVEL

In the foregoing considerations, the price-level determination equation to be employed in the present study was frequently referred to. The version of this equation presented last (equation 3.36) was as follows:

$$p = f(Y^d - Y^s, w). \tag{4.1}$$

Is this equation justifiable theoretically? And, if it is, on what grounds? As is well known, traditional analysis usually results in the equation

$$\Delta p = F_1(Y^d - Y^s). \tag{4.2}$$

It should be noted, of course, that (4.1) is a static equilibrium equation, whereas (4.2) has to do with dynamic adjustment. It might be expected, however, that there would be a degree of harmony between (4.1) and (4.2), in the sense that one could be derived from the other. This is, however, not the case; on the contrary, (4.1) and (4.2) represent (or, more correctly, are based on) two separate theories. Yet, these theories need not necessarily be mutually exclusive.

Criticisms advanced against (4.2) have been dealt with above, and only the theoretical justification of (4.1) will be discussed at this point. When demand does not equal supply, it is reasonable to expect that the difference between the two is larger, the larger the difference between the actually prevailing price level and an equilibrium price level. The price level at which supply equals demand on the commodity market is chosen here as the equilibrium price level. Thus the following hypothesis can be introduced:

$$Y^d - Y^s = F_2(p - p_o) \tag{4.3}$$

where p_o is the equilibrium price level. Let us assume further that

$$F_2'(p - p_o) < 0. \tag{4.4}$$

By (4.4), an inverse function of (4.3) exists for all values of $(p - p_o)$, or

$$p - p_o = F_2^{-1}(Y^d - Y^s) \tag{4.5}$$

and, hence,

$$p = p_o + F_2^{-1}(Y^d - Y^s). \tag{4.5'}$$

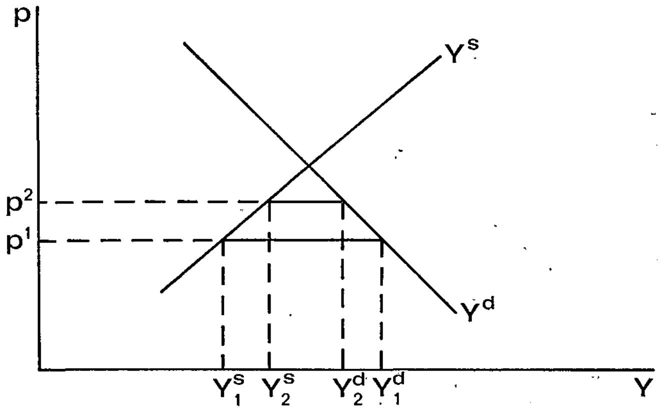

Figure 2.

The role played by the equilibrium price appears from the following. Had the equation

$$(4.5)'' \qquad p = F_2^{-1}(Y^d - Y^s)$$

rather than equation (4.5)′ been chosen as the point of departure, it would have been necessary to introduce the additional assumption that the demand and supply curves do not shift.

In Figure 2, when excess demand is $Y_1^d - Y_1^s$, the price level will be p^1; and when excess demand is $Y_2^d - Y_2^s$, the price level will be p^2. Here the price level is a decreasing function of excess demand. The situation becomes more complicated if shifts in the demand curve are permitted. Such a situation is depicted in Figure 3.

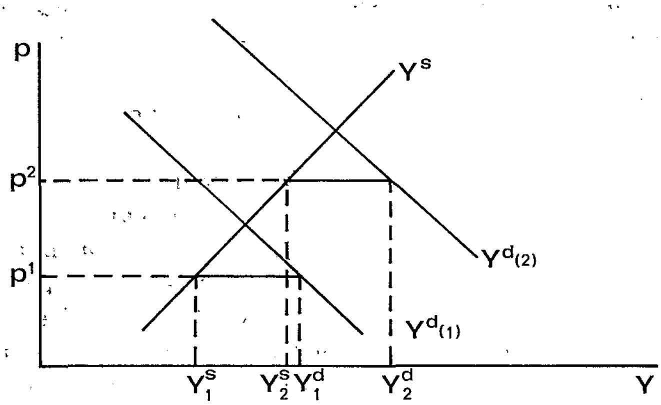

Figure 3.

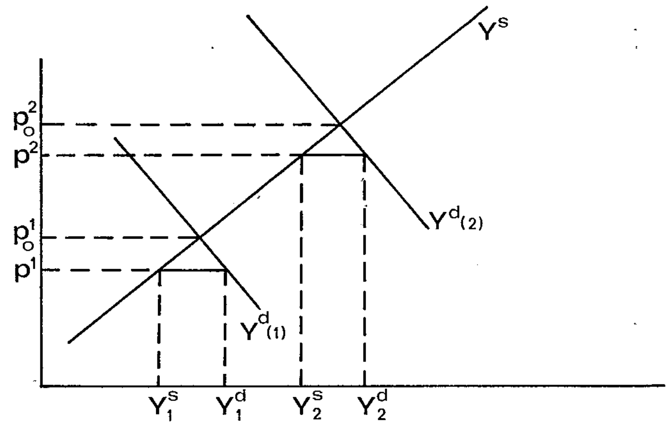

Figure 4.

In this figure the demand curve has shifted parallelly from the position $Y^d(1)$ to the position $Y^d(2)$. The amounts of excess demand, $Y_1^d - Y_1^s$ and $Y_2^d - Y_2^s$, corresponding respectively to the price levels p^1 and p^2, are, however, the same. Thus, the price level becomes indeterminate with respect to the amount of excess demand, since several different price levels can be found at which the amount of excess demand is the same.

The problem arising from shifts in the demand curve can, however, be approached by relating the price level in any particular excess demand situation to the equilibrium price level corresponding to that situation, i. e., to the price level at which supply will equal demand. The implications of this procedure are illustrated in Figure 4.

The demand curve has shifted from the position Y_1^d to the position Y_2^d, and Figure 4 represents a situation where equal amounts of excess demand, $Y_1^d - Y_1^s$ and $Y_2^d - Y_2^s$, correspond to equally large differences between the prevailing price level and the equilibrium price level, $p^1 - p_o^1$ and $p^2 - p_o^2$. The numerical value of the difference between the prevailing price level and equilibrium price level increases as excess demand increases; but the difference decreases algebraically and is, in consequence, a diminishing function of excess demand, as it should be according to assumption (4.4).

Yet it is necessary now to find an expression for the equilibrium price level p_o. When the price level at which the demand for and supply of commodities are equal is defined as the equilibrium price level, this level can be determined by means of the variables on which the demand for and supply of commodities depend. In empirical analysis the equilibrium price cannot be identified completeley, since it is never possible to take into account all the factors determining the point at which the demand and supply curves intersect, and approximations must therefore be resorted to.

Consider the following simple commodity market demand and supply functions:

$$(4.6) \qquad Y^d = G_1(p, w),\ G'_{1p} < 0,\ G'_{1w} > 0$$

$$(4.7) \qquad Y^s = G_2(p, w),\ G'_{2p} > 0,\ G'_{2w} < 0.$$

Here

$$(4.8) \qquad p_o = G(w), \quad G' > 0.$$

Substituting (4.8) into (4.5)′, the price equation becomes

$$(4.9) \qquad p = G(w) + F_2^{-1}(Y^d - Y^s).$$

The equation for the determination of the price level was derived by using the disequilibrium model as a starting point. However, equation (4.9) also permits alternative interpretations. This point will be considered below by assuming that the price is determined on the supply side. Let us suppose that the pricing principle followed by entrepreneurs is such that the price level will be a given multiple of the marginal cost, or

$$(4.10) \qquad p = k \cdot MC, \quad k > 1$$

where k is the mark-up coefficient. This coefficient is assumed to be constant here.

The capital stock can be regarded as a constant in the short run, and thus the production function will be of the form

$$(4.11) \qquad Y = \Phi(N),$$

where

$$(4.12) \qquad \Phi(N) = F_3(\bar{K}, N)$$

where $\bar{K}$ is capital stock = constant.

The expression for the marginal cost then reads (since there is only one variable factor of production):

$$(4.13) \qquad MC = w / \frac{dY}{dN}.$$

On the further assumption that the production function is of the Cobb—Douglas type, or

$$(4.14) \qquad Y = k_o N^{k_1},$$

differentiating (4.14) yields

$$\frac{dY}{dN} = k_o k_1 N^{k_1 - 1}. \tag{4.15}$$

Since, on the other hand,

$$\frac{Y}{N} = k_o N^{k_o - 1} \tag{4.16}$$

we have from (4.15), when (4.16) is taken into consideration,

$$\frac{dY}{dN} = k_1 \frac{Y}{N} \tag{4.17}$$

and, substituting into (4.13),

$$MC = w/k_1 \frac{Y}{N}. \tag{4.18}$$

Substituting (4.18) into (4.10),

$$p = \frac{k}{k_1}\left(w / \frac{Y}{N} \right). \tag{4.19}$$

On the alternative assumption that the production function is of the Leontief type, the equation corresponding to (4.19) would have been

$$p = \frac{k}{k_2} w. \tag{4.19$'$}$$

Since marginal productivity cannot be evaluated from a Leontief-type production function, it should have been interpreted to equal the constant k_2.

Equation (4.19) can also be regarded as legitimate in cases where entrepreneurs are supposed to apply the full cost pricing principle, in the sense that the price equals the wage cost per unit output as increased by a given profit margin.

In this case

$$p = k_3 (W/Y), \quad k_3 > 1, \tag{4.20}$$

where

$$W = wN. \tag{4.21}$$

The expression W/Y can be rewritten

$$W/Y = W/N : Y/N, \tag{4.22}$$

whence

$$p = k_3(W/N:Y/N) \tag{4.23}$$

and further, by substituting (4.21) into (4.23),

$$p = k_3\left(w/\frac{Y}{N}\right). \tag{4.24}$$

By (4.19) and (4.24) the proportion of nominal national income accounted for by wages is constant. WEINTRAUB[1] ended up with equation (4.24) in his price theory by starting from the assumption that wages bore a constant ratio to national income, or

$$\frac{1}{k_4} = \frac{W}{pY} \tag{4.25}$$

and further, by rearranging the terms and recollecting (4.21),

$$p = k_4\left(w/\frac{Y}{N}\right). \tag{4.26}$$

It is not, however, necessary for the share of wages in national income to be constant; for it is of course reasonable to assume that the profit margin varies according to the market situation and, in particular, that when there is excess demand, this provides entrepreneurs with an opportunity to utilize their increased monopolistic power to raise prices.[2] Then the following hypothesis can be introduced in place of (4.19):

$$p = \frac{k}{k_1}\left(w/\frac{Y}{N}\right) + k_5(Y^d - Y^s). \tag{4.27}$$

Also, (4.19)′ can be replaced by

$$p = \frac{k}{k_2}w + k_6(Y^d - Y^s) \tag{4.28}$$

when the production function is supposed to be of the Leontief type.

In this situation, however, the price level will be an increasing function of excess demand, rather than a diminishing function as in equation (4.9), which was based on the disequilibrium approach. However, the formal

1. S. WEINTRAUB A General Theory of the Price Level, Output, Income Distribution, and Economic Growth, Philadelphia 1959. See also T. HELELÄ "Uusi yleinen teoriako?" *KAK* No. 1, 1961.

2. Cf., e.g., K. ARROW "Toward a Theory of Price Adjustment", in *The Allocation of Economic Resources*, Stanford, 1959, p. 48.

similarity between equations (4.9) and (4.28), in particular, is obvious.

The following interpretation based on variations in the degree of capacity utilization can be given to the terms $k_5(Y^d - Y^s)$ and $k_6(Y^d - Y^s)$ in equations (4.27) and (4.28) respectively. Suppose that the marginal cost curve will be the steeper, the higher the degree of capacity utilization. In the full-employment situation a capacity limit is reached at which the marginal cost curve is perfectly inelastic. In other words, as output is approaching the capacity level, the influence of increasing demand on the price level, via the rise in the marginal cost, grows stronger.[3] If the terms $k_5(Y^d - Y^s)$ and $k_6(Y^d - Y^s)$ can be given an interpretation related to the degree of capacity utilization, equations (4.27) and (4.28) are also consistent with price theories based on variations in the degree of capacity utilization.

In this case, too, the price level p will be an increasing function of $Y^d - Y^s$. On the other hand, if jumps from one typical cost curve to another occur when output is expanding, each of these curves being situated below the preceding one, p will be a decreasing function of $Y^d - Y^s$. Whether the price level p is an increasing or a decreasing function of $Y^d - Y^s$ thus depends on what the latter variable is intended to measure. Here, however, the price level is assumed to be a decreasing function of $Y^d - Y^s$, since an analysis based on the disequilibrium model is in question.

The above analysis has been in the nature of short-run analysis of a closed economy. In empirical analysis, however, it is only rarely possible to make the unit period short enough to justify disregarding all long-run effects. Over the observation period covered in the present study, labour productivity, in particular, increased so markedly that consideration of the effect of changes in productivity upon the price level was also regarded as necessary. These changes will be considered in the first place as factors contributing to shifts in the commodity market supply curve. In other words, labour productivity will be dealt with as one of the determinants of the equilibrium price level.

Certain empirical studies have suggested that raw material prices can legitimately be regarded as a further determinant of movements in the price level.[4] In a model of an entire national economy, however, only the level of the prices of imported raw materials is a relevant cost component, since the raw material costs of the industry A are, as a general rule, labour costs of

3. See W. G. Bowen The Wage-Price Issue, New York 1960, p. 309 and K. Arrow cit. p. 48.

4. See, e.g., L. R. Klein & R. J. Ball "Some Econometrics of the Determination of Absolute Prices and Wages", *Econ. Jour.*, Sept. 1959 and L. R. Klein & Y. Shinkai "An Econometric Model of Japan, 1930—1959", *Int. Econ. Rev.*, Jan. 1963 and R. G. Bodkin The Wage-Price-Productivity Nexus, Philadelphia 1966.

the industries B, C, etc., and these will be taken into account mainly when the influence of the labour cost variable is estimated. Inclusion of an import price variable in the analysis means, of course, that the assumption of a closed economy must partly be abandoned. Such a procedure is justifiable, however, where the rates of foreign exchange have shown noticeable variations during a short period. The effects of the 1957 devaluation of the Finnmark were felt during the period dealt with in the present study, and therefore the inclusion of the effects of import prices in the model seems warranted.

Thus the equation for the determination of the price level to be subjected to empirical analysis can be written, on the basis of equation (4.9) and by including two additional variables, measuring changes in labour productivity and the prices of imported goods respectively, as

$$(4.29) \qquad p = a_0 w^{a_1} T^{a_2} (p^i)^{a_3} (Y^d/Y^s)^{a_4}, \qquad a_1, a_3 > 0, \quad a_2, a_4 < 0,$$

the labour productivity variable being denoted by T and the price level of imports by p^i.

The model was assumed to be exponential.[5] It was not considered appropriate to impose any *a priori* restrictions on the elasticities of p other than the requirement that their signs be consistent with the assumptions introduced. Thus, the values to be obtained through statistical estimation were considered acceptable, whatever their order of magnitude. As is well known, the values of the parameters of a model are influenced, for example, by the length of the unit period and by the choice of the lag pattern. It seems obvious, however, that in the long run $a_1 \rightarrow 1$ and $a_2 \rightarrow (-1)$. On the other hand, no *a priori* assumptions concerning the order of magnitude of the parameters a_3 and a_4 can be advanced.

4.2. DETERMINATION OF THE WAGE LEVEL

When the determination of the wage level was considered in Chapter 3, the following equation analogous to the determination of the price level equation was chosen as the point of departure:

$$(4.30) \qquad w = g(N^d - N^s, p).$$

Hypotheses comparable to those presented in considering the theoretical justification of the determination of the price level equation can be put for-

5. The mathematical form of the model will be discussed in a later context. Likewise, the possible time lags between the variables will be considered later.

ward to justify equation (4.30) theoretically. Comparison of equation (4.30) with the equation

$$\Delta w = F_3(N^d - N^s), \tag{4.31}$$

reveals that here, too, two different theories are in question. Also, the difference between the demand for and supply of labour can be supposed to be larger, the larger the difference between the prevailing wage level and the equilibrium wage level, defined in one way or another; or, in symbols

$$N^d - N^s = F_4(w - w_0), \tag{4.32}$$

where w_0 is the equilibrium wage level.

Assume now that

$$F_4' \, (w - w_0) < 0. \tag{4.33}$$

The inverse function of (4.32) can then be written

$$w - w_0 = F_4^{-1}(N^d - N^s) \tag{4.34}$$

whence

$$w = w_0 + F_4^{-1}(N^d - N^s). \tag{4.34$'$}$$

Analogously to the case with the equilibrium price level, the equilibrium wage level can be defined in terms of the point of intersection of the labour market demand and supply curves. Consider the following simple labour demand and supply functions:

$$N^d = H_1(p, w), \qquad H'_{1p} > 0,\ H'_{1w} < 0, \tag{4.35}$$

$$N^s = H_2(p, w), \qquad H'_{2p} < 0,\ H'_{2w} > 0. \tag{4.36}$$

Here,

$$w_0 = H(p), \qquad H' > 0. \tag{4.37}$$

Substituting w_0 from (4.37)into (4.34)', the following wage equation is obtained:

$$w = H(p) + F_4^{-1}(N^d - N^s). \tag{4.38}$$

The problem will be approached here from the demand side. The equilibrium condition stating that more labour will be demanded until the real wage equals the marginal productivity of labour or, in symbols,

$$w/p = dY/dN \tag{4.39}$$

can then be chosen as the starting point.

If the production function is of the Cobb—Douglas type or

$$Y = k_o N^{k_1}, \tag{4.40}$$

the following wage equation is obtained:

$$w = k_1 \, p \frac{Y}{N} \tag{4.41}$$

and if it is of the Leontief type, the wage equation reads

$$w = k_2 \, p. \tag{4.42}$$

Equations formally similar to (4.42) may also be arrived at when certain other hypotheses are chosen as the point of departure. It may be assumed, for example, that the labour market organizations seek to keep the share of wages in the national income constant or, in symbols,[6]

$$w \, N = k_3 \, p \, Y, \tag{4.43}$$

whence, by solving for w,

$$w = k_3 p \frac{Y}{N}. \tag{4.44}$$

Equation (4.41) permits some further assumptions. The share of wages in the national income need not necessarily be constant; it may vary, for instance, according to the labour market demand and supply conditions, since these obviously affect the bargaining power of the parties concerned and, hence, the wage level agreed on through wage negotiations.[7] Equation (4.41) may therefore be replaced by the following hypothesis:

$$w = k_1 \, p \frac{Y}{N} + k_4 (N^d - N^s). \tag{4.45}$$

Correspondingly, (4.42) may be replaced by

$$w = k_2 \, p + k_5 (N^d - N^s). \tag{4.46}$$

The formal similarity of equations (4.38) and (4.46) is obvious; but in the latter case the wage level is an increasing function of $N^d - N^s$, since the bargaining power of the unions can be taken to be an increasing function of the excess demand for labour.

6. Equations (4.41) and (4.43) are formally completely similar. However, the first has to be interpreted as a behavioural equation, whereas the second is a definition.

7. Cf. E. Kuh »A Productivity Theory of Wage Levels — An Alternative to the Phillips Curve», *Rev. Econ. Stud.*, Oct. 1967, p. 399.

Here, too, there is reason to take certain long-run effects into consideration in empirical analysis. In particular, variations in the productivity of labour as a factor contributing to shifts in the demand for labour curve and to changes in the equilibrium wage corresponding to the point of intersection of the demand and supply curves, seem to merit attention.

In the empirical study of the determination of wages, certain institutional variables have been resorted to. These include variables measuring the degree of organization of workers and employers[8], those measuring changes in the political situation[9] and various propensity to strike variables.[10] Yet the explanatory power of such variables has proven only marginal, in comparison with the other explanatory variables involved. In the present study, however, it is necessary to take a stand on certain questions relating to the prevailing institutional conditions. The determination of wages is influenced, of course, by decisions taken on the demand side as well as those taken on the supply side. Yet, the price index relevant to the demand side is some price index of output, whereas the relevant price index on the supply side is the cost of living index.[11] If the two indices move in the same direction, no problem will, of course, arise; but as the two indices differ both in commodity composition and weighting pattern, they are very seldom likely to move uniformly.[12]

Thus, the following determination of the wage level equation, suitable for an empirical analysis resting on a disequilibrium model, which is based on equation (4.38) can be introduced. It includes variations in the productivity of labour and the discrepancy between the movements in the cost of living index and the index of the general price level as additional variables:

$$(4.47) \qquad w = b_0 p^{b_1} T^{b_2} (p^e/p)^{b_3} (N^d/N^s)^{b_4}, \quad b_1,\ b_2,\ b_3 > 0,\ b_4 < 0,$$

where p^e is the cost of living index, the other symbols being the same as in previous equations.

Again, no *a priori* restrictions on the order of magnitude of the elasticities involved will be introduced. Obviously, however, $b_1 \to 1$ and $b_2 \to 1$ in the

8. See, e.g., S. Valavanis-Vail "An Econometric Model of Growth: U.S.A. 1869—1953", *Am. Econ. Rev., Papers and Proceedings,* May 1955.

9. See, e.g., L. R. Klein & R. J. Ball "Some Econometrics of the Determination of Absolute Prices and Wages", *Econ. Jour.,* 1959.

10. See, e.g., A. Molander "Eräs ekonometrinen koe hintojen ja palkkojen selitysmallin konstruoimiseksi", Helsingin yliopisto 1964.

11. Cf. E. Kuh "A Productivity Theory of Wage Levels — An Alternative to the Phillips Curve", *Rev. Econ. Stud.,* Oct. 1967, p. 340.

12. A. Molander "Interdependence between Prices and Wages", *KAK* No. 3, 1968.

long run. It will be required, however, that the signs of the elasticities concerned be compatible with the assumptions advanced.

Certain empirical wage studies have attempted to explain variations in wages in terms of entrepreneurs' profits.[13] Some of the results have been quite promising. Nevertheless, divergent views are held for the present by various wage theorists regarding the explanatory power of profits. The theoretical justification of the profit theory of wages rests on a rather flimsy basis, and the empirical explanatory power of profits may be a consequence of a more complicated network of relationships. KALDOR, who is the most prominent exponent of the profit theory of wages, maintains that PHILLIPS (who explains wage changes in terms of excess demand for labour) has obtained his correlations solely because excess demand on the labour market and entrepreneurs' profits are intercorrelated.[14] This issue will be considered below by means of equation (4.47).

Assume, for a while, that $T = Y/N$, $b_1 = b_2 = 1$ and $b_3 = 0$, so that

$$w = b_o p(Y/N)\,(N^d/N^s)^{b_4}, \tag{4.48}$$

from which

$$N^d/N^s = b_o^{-\frac{1}{b_4}}\,(pY/wN)^{-\frac{1}{b_4}} \tag{4.49}$$

can be derived.

In this equation pY/wN measures the profit margin. The wage adjustment equation in Phillips's analysis is of the form

$$\Delta w = F_3(N^d - N^s). \tag{4.50}$$

Yet, when equation (4.49) is taken into consideration, it is completely immaterial whether w is regarded as a function of excess demand N^d/N^s or of the profit variable pY/wN.

Therefore, providing that (4.50) is regarded as a realistic wage adjustment model, the model developed here can be employed to demonstrate that, under conditions the occurrence of which is probable, Kaldor's assertion is justifiable. It is legitimate to maintain, on the other hand, that the relationship between wages and excess demand is direct, while that between wages

13. See, e.g., R. J. BHATIA "Unemployment and the Rate of Change in Money Earnings in the United States, 1935—59", *Economica*, Aug. 1961; R. G. LIPSEY & M. D. STEUER "The Relation between Profits and Wage Rates", *Economica*, May 1961; and J. T. DUNLOP "The Task of Contemporary Wage Theory" in *The Theory of Wage Determination*, ed. John T. Dunlop, London — New York 1957.

14. N. KALDOR "Economic Growth and the Problem of Inflation, Part II", *Economica*, Nov. 1959.

and profits is indirect, and not the other way round as Kaldor maintains. At least within the framework of the model developed here, there is a direct association between wages and the excess demand for labour. It would seem, however, that a profit variable might be employed in place of the excess demand variable where no sufficiently good operational counterpart of the latter is available. Under certain circumstances, profits and the wage level may be directly correlated in practice. If $b_1 = b_2 = b \neq 1$, the equation (4.48) can be written

$$(4.51) \qquad w = b_0^{\frac{1}{1-b}} (pY/wN)^{\frac{b}{1-b}} (N^d/N^s)^{\frac{b_4}{1-b}}$$

This establishes a direct relation between the profit margin (pY/wN) and the wage level w.

4.3. THE DEMAND FOR LABOUR

One of the oldest controversies in economics is the one concerned with the demand for labour function. Hence, a number of alternative solutions are available for the construction of a demand for labour function suitable for the purposes of the present study. In the classical and Keynesian models, this function was based on the marginal productivity theory, according to which more labour was demanded until its marginal productivity equalled the real wage. The equilibrium condition corresponding to this view reads

$$(4.52) \qquad \frac{w}{p} = \frac{dY}{dN}$$

In the short run employment is lower, the higher the real wage, and *vice versa*. This follows from the fact that a decline in the marginal productivity of labour can be expected at a certain stage, so as to make it profitable to substitute capital for labour.

Substitutability is a necessary condition for the marginal productivity theory to be meaningful, since in the absence of substitutability marginal productivities cannot be computed. The possibility of substitution is the factor that permits variations in the demand for labour independently of the demand for commodities.[15] A rise in the real wage level renders so-called marginal production unprofitable at the prevailing prices, and the demand for labour will diminish unless the price level rises. In practice, however, the possibilities of substitution are limited at least in the short run. This fact furnishes a basis for the Leontief-type production functions, for example,

15. J. D. PITCHFORD A Study of Cost and Demand Inflation, Amsterdam 1963, p. 11.

which do not allow for the existence of substitution possibilities but postulate, instead, a fixed relationship between labour input and output. These functions do not also involve relative prices as a determinant of the demand for labour.

A Leontief-type production function appears preferable in an empirical study, since the computation of marginal productitivities is obviously impossible in practice. To avoid the occurrence of marginal productivities in his theoretical model, Pitchford assumed that the demand for labour in money terms, measured by the wage bill, depended on the demand for commodities in money terms. When he then split up the value sums into price and volume components, he obtained a function according to which the demand for labour was dependent on the volume of demand in the commodity market and on the real wage level.[16] This procedure cannot, however, be applied here, since the model to be employed in the empirical analysis will not include, because of difficulties in measurement, any commodity market demand and supply equations.

Here we may start from the assumption, employed in the construction of the price and wage functions, that the capital stock remains constant in the short run; thus

$$\frac{dY}{dN} = a_1 \frac{Y}{N}. \tag{4.53}$$

Substituting (4.53) into (4.52) and solving for N,

$$N = a_1 Y / \frac{w}{p}. \tag{4.54}$$

According to (4.54) the demand for labour is directly proportional to the volume of output and indirectly proportional to the real wage. Equation (4.54) can also be derived in another way.[17] Assume that entrepreneurs are not able to compute marginal productivities and that they do not seek to maximize their profits, at least not consciously. They merely seek to secure themselves a given profit margin per unit of output; or, in symbols,

$$pY - wN = xpY, \tag{4.55}$$

where x is the profit margin.

Rearranging the terms in (4.55),

$$\frac{w}{p} = (1 - x) \frac{Y}{N} \tag{4.56}$$

16. J. D. Pitchford op. cit. pp. 27—28.
17. See J. D. Pitchford op. cit. pp. 11—12.

and further

$$N = (1 - x)\, Y / \frac{w}{p}. \tag{4.57}$$

In order to keep their profit margins unchanged it is necessary for entrepreneurs to vary their demand for labour when changes take place in the real wage level. When the system approaches full employment equilibrium, capital will increasingly be substituted for labour until a point is reached at which output per unit of labour begins to diminish and employment cannot be increased, except by reducing the real wage (assuming that as the level of employment varies, the volume of output per unit of labour also varies).

The demand for labour function has been investigated empirically to a very minor extent. In the »Brookings» model, for instance, the demand for labour function was obtained directly from the production function by solving it for the labour input. A kind of implicit production function was thus arrived at, and the function was also estimated in this form. In consequence, the demand for labour came to depend on the volume of output and on the capital stock. Relative prices were disregarded in the model.[18] KLEIN[19] has estimated demand for labour equations that can be interpreted to rest directly on equation (4.54). Before estimating the model, however, he solved it for the total wages to obtain

$$N w = a_1 p\, Y, \tag{4.58}$$

and estimated it in this form.

This enabled Klein to find an estimate for N from the calculated value of Nw by employing a separate explanatory equation for w. The function in (4.58) has the merit that it satisfies the classical homogeneity assumption, the demand for labour depending on the wage-price ratio.

TINTNER endeavoured to test the empirical explanatory power of the homogeneity assumption by postulating that the demand for labour depended directly on prices and wages, no profit maximization assumption or production function being involved in his model.[20]

18. E. KUH "Income Distribution and Employment over the Business Cycle" in *The Brookings Quarterly Econometric Model of the United States*, ed. J. S. Duesenberry et al., Chicago—Amsterdam 1965.

19. L. R. KLEIN Economic Fluctuations in the United States: 1921—1941, New York 1950 and L. R. KLEIN & A. S. GOLDBERGER An Econometric Model of the United States 1929—1952, Amsterdam 1955.

20. G. TINTNER Econometrics, New York 1952.

Only very recently have attempts been made to include relative prices as an explicit element in the demand for labour function.[21]

The choice of a demand for labour equation suitable for empirical analysis can now be considered on the basis of the above discussion.[22] If equation (4.54) is chosen as the starting point, the demand for labour function to be subjected to empirical analysis can be written as follows:

$$(4.59) \qquad N^d = c_0 Y^{c_1} (w/p)^{c_2}, \qquad c_1 > 0, \; c_2 < 0.$$

When relative prices are included in the demand for labour function as an explicit independent variable, the causal chain is allowed to run from the price and wage levels to unemployment, as well as from unemployment to the price and wage levels.

The function (4.59) is a short-run demand for labour function. The variable Y links this function with the production function, and the parameter corresponding to it combines the restrictions imposed by the production function on the demand for labour.

At this point it is also necessary to consider how far certain possible long-run influences should be allowed for in empirical analysis. In the context of constructing the price and wage equations we stated that the rise in labour productivity over the period of observation was so rapid that its inclusion as an explanatory variable in the demand for labour function seemed warranted. The question of variations in productivity as a factor influencing the relationship between the demand for labour and total output has often been encountered in the study of the production function, since it is reasonable to suppose that an increase in the productivity of labour at an unchanged volume of output may result in a decrease in the demand for labour.

When the productivity variable is introduced, (4.59) becomes

$$(4.60) \qquad N^d = c_0 Y^{c_1} (w/p)^{c_2} T^{c_3}, \qquad c_1 > 0, \; c_2, \; c_3 < 0.$$

No *a priori* restrictions will be imposed on the elasticities of the demand for labour with respect to the volume of output, the real wage level or the productivity of labour.

21. M. I. Nadiri "The Effects of Relative Prices and Capacity on the Demand for Labor in the U.S. Manufacturing Sector", *Rev. Econ. Stud.*, July 1968.

22. See also footnote 5 on p. 22.

4.4. THE SUPPLY OF LABOUR

Empirical models usually include the supply of labour as an exogenous variable.[23] This is due to two different reasons. First, the results obtained in the rare cases where attempts have been made at an empirical determination of supply of labour functions have been rather discouraging. G. TINTNER, for example, who tested the empirical legitimacy of the homogeneity assumption concerning the classical supply of labour function, obtained a negative sign for real wages, instead of the positive sign suggested by *a priori* assumption.[24] Secondly, the view has been rather wide-spread that the supply of labour bears a comparatively constant ratio to the total population and changes only slowly, as a result of changes in certain non-economic factors. DUESENBERRY, for example, states that »labour-force participation rates are largely determined by social attitudes, by techniques of production, and by economic factors which are only indirectly related to the balance of supply and demand in the labour market, e.g. the effect of the level of real income on the school leaving and retirement ages.»[25]

Duesenberry's view also finds support in some empirical studies.[26] On the other hand, there are research results suggesting that short-term changes, dependent on a variety of factors, do occur in the number of those willing to work. This observation has provided a stimulus for some empirical studies in which special efforts have been made to explain short-run variations in the supply of labour.[27] One of these rare attempts to endogenize the supply of labour function, known to the present writer, is that made in connection with the above-mentioned Brookings model.[28] In that study, unemployment, the weekly hours worked and the outstanding amount of consumer credit, for example, were used to explain the labour force participation rate. The use of unemployment as an explanatory variable should be commented on briefly in this context. For one thing, it is by no means obvious on *a priori* grounds which sign this variable can be expected to have in the supply of labour function, since it is possible to distinguish influences operating in both directions. Lack of employment opportunities may be assumed to in-

23. The Klein—Goldberger model, for example, is such.

24. G. TINTNER op. cit.

25. J. S. DUESENBERRY Business Cycles and Economic Growth, New York 1958, p. 310.

26. See C. D. LONG The Labor Force under Changing Income and Employment, NBER, Princeton 1958.

27. See, e.g., L. HANSEN "The Cyclical Sensitivity of the Labor Supply", *Am. Econ. Rev.*, June 1961, pp. 299—309.

28. S. LEBERGOTT "The Labor Force and Marriages as Endogenous Factors" in *The Brookings Quarterly Econometric Model of the United States*, ed. J. S. Duesenberry et al., Chicago—Amsterdam 1965.

fluence some marginal workers in such a way that they do not appear in the labour market at all. On the other hand, the unemployment of one family member may induce other family members who have not previously belonged to the labour force to seek employment. In some recent studies efforts have been made to consider these so-called »discouraged worker» and »additional worker» hypotheses separately, by choosing variables by means of which the influences running in the opposite directions could be accounted for.[29] However, when the supply of labour and unemployment are related to each other, an undesirable element of simultaneity is introduced into the model, since not only the demand for but also the supply of labour, i.e., the variable to be explained, is among the determinants of unemployment. Furthermore, the operational content of the unemployment variable is almost the same in this model as that of the variable measuring the average hours worked per week — both being variables describing the cyclical situation. Nevertheless, the variable describing the average weekly hours can also be assumed to have an effect that is independent of the cyclical situation, since as the result of a reduction in weekly hours worked more labour may be hired with the object of keeping the labour input unchanged. Here, however, unemployment is influenced through the demand for labour, and a negative sign could be expected in this case.

The significance of the supply of labour function will remain slight unless it is possible to have the causal chain run not only from the demand for labour to the other endogenous variables via the other equations of the model, but also from the other endogenous variables to the supply of labour. If the demand for labour were expressed solely as a function of explanatory variables similar to those included in the Brookings model, the causal relationship would remain one-sided, since these variables are exogenous from the standpoint of the present model. The supply of labour obviously depends on the growth of the population, and since the function to be constructed here is intended to explain changes in the labour force rather than variations in the number of those willing to work, it is legitimate to include total population as one of the independent variables in the supply of labour function.[30] To arrive at a two-way causal relationship between the supply of labour and the other endogenous variables of the model, the real wage level can be introduced, on the basis of the classical supply function of labour, as a second independent variable, so that the supply of labour function will read

29. See K. Strand & T. Dernberg "Cyclical Variation in Civilian Labor Force Participation", *Rev. Econ. Stat.*, Nov. 1964.

30. It should be pointed out that the inclusion of a variable measuring population growth also introduces certain long-run effects into the model.

$$(4.61) \qquad N^s = d_0 V^{d_1}(w/p)^{d_2}, \qquad d_1, d_2 > 0,$$

where V = the population of working age.

The introduction of a variable describing changes in relative prices (w/p) means in itself that the supply of labour is assumed to be homogeneous with respect to prices and wages. The empirical studies carried out also suggest that the attitudes of those willing to work are sensitive to changes in demand conditions, with the result that part of the labour force may fail to offer itself in the labour market, while others may be increasingly willing to seek employment. To be able to measure the net effect, some attitude variable has to be included in the model; yet, to avoid undesirable simultaneity, this variable should be chosen in such a way that, rather than reflecting demand conditions on the labour market, it will describe those on the commodity market. The model (4.61) will then be replaced by

$$(4.62) \qquad N^s = d_0 V^{d_1}(w/p)^{d_2}(Y^d/Y^s)^{d_3}.$$

No *a priori* restrictions will be imposed on the parameters. No assumptions can be made concerning their order of magnitude, except that the elasticity of the supply of labour with respect to the total population is likely to be almost unity in the long run, whereas its elasticities with respect to relative prices and the attitude variable are likely to be rather small. The sign of the elasticity of the supply of labour with respect to relative prices is assumed to be positive *a priori*, whereas the sign of its elasticity with respect to the attitude variable is left to depend on the statistical estimation of the model.

4.5. EXCESS DEMAND IN THE COMMODITY MARKET

The commodity market plays a rather passive role in this study, in the sense that the model will not include any commodity demand or supply functions. Since, on the other hand, the price equation involves the excess demand for commodities as an explanatory variable, a closer consideration of the relationships prevailing in the commodity market is regarded as appropriate at this point because, among other things, an operational counterpart has to be found for this concept of excess demand.

What makes this task difficult is principally the fact that the demand for and supply of commodities are *ex ante* variables or »desired» quantities.[31] Thus, the excess demand for commodities is the difference between two *ex*

31. See, e.g., B. Hansen A Study in the Theory of Inflation, London 1951, p. 22.

ante variables and, hence, an *ex ante* variable itself. The statistical data available on *ex ante* variables is quite scanty, however, and they must therefore be replaced by suitable *ex post* variables in empirical investigations.

The statistical data available on output represents the result of an interaction of the decisions taken by decision units on the demand and supply sides. When there is excess demand, the realized output exceeds the desired supply but falls short of the desired demand, and when there is excess supply *vice versa*. Hence, the realized output is likely to be somewhere between demand and supply.

If the process of adjustment is such as was assumed when the theoretical model of this study was constructed, realized output equals demand in the case of excess supply and supply in the case of excess demand.

If it were legitimate to assume that realized output always equals demand and that the difference between demand and supply can always be bridged by either increasing or decreasing stocks, the ratio

$$\frac{\text{output} + \text{change in stocks}}{\text{output}}$$

could be used as a measure of the excess demand for commodities.

The numerator of this expression would then be demand and the denominator would be supply. The available observational data is, however, too deficient to permit the application of such an indicator of excess demand.

It has also been suggested that a variable based on unfilled orders might be used as a basis for the construction of the demand variable.[32] The available data does not, however, permit the application of this procedure either.

A variety of feasible operational solutions for the problem have been proposed in the literature. These are based, in the main, on the following two additional hypotheses:

(a) Excess demand for commodities is an increasing function of excess demand for labour.

(b) Excess demand for commodities is an increasing function of the degree of capacity utilization.

Dicks-Mireaux's study of the United Kingdom economy and Neild's study of industry in the United Kingdom, for example, are based on Hypothesis (a).[33] The results of both studies suggest that the effect of excess

32. See, e.g., E. Kuh "Profits, Profit Markups, and Productivity", Study Paper No. 15, prepared for the Joint Economic Committee of the United States Congress, Study of Employment, Growth and Price Levels, Washington 1960.

33. L. A. Dicks-Mireaux "The Interrelationship between Cost and Price Changes 1946—1959: A Study of Inflation in Post-War Britain", *Oxf. Econ. Papers,* Oct. 1961; and R. R. Neild Pricing and Employment in the Trade Cycle, London 1963, pp. 267—292.

demand on the price level is quantitatively slight. Moreover, the excess demand variable constructed in this way obtained a negative coefficient in both studies, contrary to the *a priori* assumptions advanced.[34]

An argument put forward by Neild in support of the use of an indicator of excess demand for labour as the operational counterpart of excess demand for commodities is that the pressure of demand for labour can be assumed to move closely in line with the pressure of demand for products.

This assumption need not, however, necessarily be tenable where demand and supply in the commodity and labour markets are subject to considerable exogenous influences, so that they may move in opposite directions.

Several studies based on Hypothesis (b) have been carried out.[35] EDVIN KUH measured the degree of capacity utilization by means of the ratio between current output and the maximum output achieved during the last cyclical upswing. To obtain a capacity variable related to the current period, however, this maximum output was adjusted by making allowance for the growth in productive capacity (which averaged 3 3/4 per cent per annum over the period of observation concerned). Kuh obtained a statistically significant positive coefficient for this variable, according to which the excess-demand elasticity of the price level was 0.22.[36]

In the Brookings model the ratio between volume of output and capital stock as measured at constant prices was employed as the measure of productive capacity, and the degree of capacity utilization was measured by the difference between this ratio variable and the trend shown by it. The departure from its own trend of the ratio between stocks and output was also tried out as the demand variable. The results obtained did not, however, permit positive conclusions.[37] BODKIN carried out experiments with two different capacity variables: the relative deviation of industrial output from its 9-year geometric mean, on the one hand, and from its own trend, on

34. A similar result was also obtained by the present writer in his previous studies; see A. MOLANDER "Interdependence between Prices and Wages", *KAK* No. 3, 1968.

35. E. KUH op. cit.; C. L. SCHULTZE & J. L. TRYON "Prices and Wages" in *The Brookings Quarterly Econometric Model of the United States*, ed. J. S. Duesenberry et al., Chicago—Amsterdam 1965; W. J. YORDON, Jr. "Industrial Concentration and Price Flexibility in Inflation, Price Response Rates in Fourteen Industries, 1947—1958", *Rev. Econ. Stat.*, Aug. 1961, pp. 287—294; J. V. YANCE "A Model of Price Flexibility", *Am. Econ. Rev.*, June 1960, pp. 401—418; and R. G. BODKIN The Wage-Price-Productivity Nexus, Philadelphia 1966. In the last four studies, the hypothesis concerning the asymmetry of the responses of the price level with respect to the explanatory variables was investigated, in addition. The results did not, however, support such a hypothesis.

36. E. KUH op. cit. pp. 83—84.

37. C. L. SCHULTZE & J. L. TRYON op. cit.

the other. Positive, statistically significant estimates were obtained for the variables. The excess-demand elasticities of the price level were, however, as small as 0.06 and 0.09. Bodkin concluded that the significance of demand variables in the explanation of variations in the price level is of a secondary nature.[38]

Thus, previous studies are of little help when an attempt is made to construct a demand variable suitable for the price equation of the present study.

Initially, however, the assumption chosen as the point of departure was that the excess demand for commodities can be measured by means of the ratio between realized output and some output trend variable. This ratio might also be called a measure of the degree of capacity utilization. When quarterly observations for the years 1957—1966 were employed, the following semi-logarithmic trend was found for total output:

$$(4.63) \qquad \log Y = 1.980 + \underset{(.0002)}{.0055} \cdot t \qquad R = .979$$

In so far as the commodity market supply can be measured by means of this trend, which might be called the growth path of the "normal" degree of capacity utilization, there is only little scope for variation about this trend: judging by the high coefficient of correlation, the trend fits the observations very closely. Hence, the operational counterpart of Y^d/Y^s, i.e., the ratio that total output bears to its own trend, also shows only slight variations. Empirical measurement can only show, therefore, how far the price level responds to such slight variations in "excess demand".

It should be pointed out in this context that, in the present model, excess demand for commodities is assigned an exogenous and excess demand for labour an endogenous role. Both variables are, however, endogenous by nature, and only the absence of suitable statistical data makes it imperative to consider the commodity market excess demand as an exogenous element.

The situation can, however, be remedied if a common endogenous excess demand variable can be found for the commodity and labour markets that is a function of the excess demand variables of the two markets.

The model used by Klein and his associates includes the average number of hours worked as one indicator of total demand; in this model, variations in this variable are explained simply by variations in the volume of output.[39]

In view of the above discussion, however, the explanatory equation relevant

38. R. G. Bodkin op. cit. pp. 174—177.

39. L. R. Klein, R. J. Ball, A. Hazlewood & P. Vandome An Econometric Model of the United Kingdom, Oxford 1961, pp. 115—120.

to the present study is one in which the average number of hours worked is a function of the individual excess demand variables or, in symbols,

$$h = f_o\ (N^d/N^s)^{f_1}(Y^d/Y^s)^{f_2}, \quad f_1 < 0, f_2 > 0. \tag{4.64}$$

The assumptions concerning the signs require a few words of explanation. Variations in the average number of hours worked measure the variation in the degree of labour utilization. Total labour input can be increased, therefore, either through increasing the degree of labour utilization or through raising the employment rate; if labour input remains the same and the first is increased, the second must decrease, and *vice versa.* The estimate of the elasticity f_1, corresponding to the labour market excess demand must have a negative sign.

The elasticity of h with respect to the commodity market excess demand variable can, by contrast, be expected to have a positive sign. If the degree of labour utilization and commodity market excess demand are considered as theoretical variables, the direction of the dependence between these two is not self-evident, although it is obvious that the degree of labour utilization rises as the excess demand for commodities increases, and *vice versa.* On the other hand, the problem is easier to approach when the operational counterparts of these variables are in question. The operational counterpart of Y^d/Y^s employed here also measures the degree of productive capacity utilization; the degree of labour utilization can then be expected to change in the same direction, at least in the short run, as the degree of productive capacity utilization.

5. EMPIRICAL PARTIAL ANALYSIS

5.1. GENERAL REMARKS

Every econometric model necessarily represents a compromise of one sort or another. The present study is no exception to this rule, particularly as the theoretical variables of the model have to be replaced by operational variables bearing only a more or less close resemblance to them. Moreover, a number of simplifications must usually be introduced. Here, for example, the commodity market demand and supply situation is assumed to be an exogeneous element of the model. It is hard to infer *a priori* how closely the operational variables selected correspond to the theoretical variables, and thus it will be difficult to appraise the goodness of the empirical results. The following criteria will be employed here:

(1) In order for a variable to be included in the final model, the estimate of its corresponding parameter has to be statistically significant.

(2) The signs of the parameter estimates have to be consistent with the *a priori* assumptions.

(3) The numerical values of the estimates have to be reasonable with respect to their order of magnitude, in the sense that, when the model is considered as a whole, they do not lead to unreasonable final equations.

(4) The multiple correlation coefficient for each individual equation has to deviate significantly from zero.

To arrive at a »readable» model, the following additional criteria were introduced:

(5) The number of variables in the total model should be the smallest possible, primarily in the sense that those variables that contribute merely marginally to the explanation, or are otherwise irrelevant to the problem in hand, are to be excluded.

(6) The variables should be manipulated to the smallest extent possible.

The data employed consisted of quarterly figures for the Finnish economy from the years 1957—1966. In a sense, it would have been more appropriate to use the years 1958—1966 as the sample period, since certain figures associated with the behaviour of the labour market are available only from the beginning of 1958. Nevertheless, in order for the effects of the devaluation of the Finnmark effected in autumn 1957, to be reflected clearly enough in the data, it was considered preferable to include the year 1957 and to employ crude estimates where statistical labour market figures were not available.[1]

1. The statistical data and the sources of data are presented in Appendix III.

The use of quarterly observations necessitated facing the problem of seasonal variations. Since comparatively little is known for the present about how far the various mechanical methods of seasonal adjustment leave the other components of a time series unchanged, it seemed preferable to use original rather than seasonally adjusted statistical time series in the study. Hence, in order to allow for seasonal variations, explicit seasonal variables S_i (i = 1,2,3) were introduced into the equations of the model as additional independent variables; of these, S_1 obtained the value 1 during the first quarter and was equal to zero in the other quarters, S_2 obtained the value 1 in the second quarter and equalled zero in the other quarters, etc. The seasonal components in the fourth quarter were allowed for by the constant parameters of the equations.

Exponential functions, linear in logarithms, were employed, because some preliminary experiments had suggested that these were superior to ordinary linear functions. The sharply rising trends shown by prices, wages and output during the sample period also suggested the use of functions linear in logarithms. On the other hand, since many of the equations were non-linear in the variables even when functions linear in logarithms were employed, it was considered advisable, even at the estimation stage, to use a functional form the analytic properties of which would facilitate the analysis of the economic and economic-policy implications of the model and that of its dynamic properties.

At this stage the model will be considered equation by equation. Only in the next chapter, when the partial analysis of the present chapter has led to the discovery of satisfactory structural components, will the model be considered as a whole and estimated simultaneously.

5.2. THE PRICE EQUATION

Initially, the following stochastic basic equation, resting on the hypothesis (4.29) advanced in Chapter 4, was estimated:

$$(5.1)\quad p = a_o(w^e)^{a_1}(T)^{a_2}(p^i)^{a_3}(Y^d/Y^s)^{a_4}e^{u_1}$$

$$a_1, a_3 > 0, \quad a_2, a_4 < 0,$$

where p = the price index of gross domestic product at factor cost, w^e = the index of the earnings level of wage and salary recipients, T = the productivity of labour, as measured by the ratio of gross domestic product at factor cost to total labour input, p^i = the unit value index of imports, Y^d/Y_s.

= the volume of gross domestic product as divided by its own exponential trend, u_1 = the error term and e = the base of natural logarithms.

The result obtained by estimating the equation by the ordinary method of least squares was[2]

$$
\begin{aligned}
(5.2)\quad ln\,p = {} & 1.829 + .626\,ln\,w^e - .046\,ln\,T + .052\,ln\,p^i \\
& \qquad (18.650) \qquad (.720) \qquad (.316) \\
& - .143\,ln\,(Y^d/Y^s) + .002\,S_1 - .012\,S_2 + .025\,S_3 \\
& \quad (3.058) \qquad\qquad (.383) \quad (2.218) \quad (4.150) \\
& R = .996 \quad D\text{—}W = 1.807
\end{aligned}
$$

Only the estimates of the coefficients of the earnings level and excess demand variables were both statistically significant and consistent with the *a priori* assumptions in respect to their signs. The signs of the estimates of the coefficients of the productivity and import price variables were also consistent with the respective *a priori* assumptions, but they did not differ statistically significantly from zero.

To improve the result, attention was first given to the import price variable p^i. Two components, namely, the unit value index of imported raw materials and that of imported investment goods, denoted respectively by p^{ir} and p^{ii}, were singled out. The first was assumed to influence the general price level through variable costs and the second through fixed costs.[3] Experiments were carried out under alternative assumptions concerning these new import price variables and the demand variable Y^d/Y^s: they were supposed to affect the general price level either without lag or with a lag of two quarters. The results are given in Appendix I Table 1 (equations (5.3) — (5.9)).

The results provided certain suggestions that were helpful in further experiments. They indicated, first, that the interdependence of p^{ir} and p^{ii} seemed to make it difficult to separate out the independent effects of these variables. Secondly, the unlagged demand variable obviously correlated at least with the wage variable, for the estimate of the coefficient of this variable was statistically more significant always when the variable occurred in

2. The t values for the parameter estimates are given in brackets. R is the coefficient of multiple correlation and $D — W$ is the Durbin—Watson autocorrelation test variable. The calculations were carried out by employing the electronic computers of the Bank of Finland, the Massachusetts Institute of Technology and the Finnish Cable Company. The computer programmes employed did not differ appreciably from one another.

3. Variations in fixed costs reflect long-run effects. Only the shock effect of devaluation on this variable justified its inclusion in the model.

the equation with a lag, as compared with cases where it was unlagged. To solve the problem presented by the import price variables they were weighted together, by employing as weights the 1962 shares of raw materials and investment goods in imports. The weight assigned to p^{ir} was 0.61 and that assigned to p^{ii} was 0.39. Appendix I Table 1 also reveals that the estimates of the parameter corresponding to the import price variable thus obtained differed more significantly from zero when the variable was lagged by two quarters than in cases where it occurred in the model without a lag. The result obtained when both the new import price variable p^{imp} and the demand variable Y^d/Y^s were lagged two quarters was as follows:

$$
\begin{aligned}
(5.10)\quad \ln p &= \underset{(11.941)}{1.826} + \underset{(20.127)}{.664} \ln w^e - \underset{(2.721)}{.183} \ln T + \underset{(4.271)}{.122} \ln p^{imp}_{-2} \\
&\quad - \underset{(.301)}{.022} \ln (Y^d/Y^s)_{-2} + \underset{(.500)}{.003} S_1 - \underset{(2.706)}{.015} S_2 + \underset{(3.731)}{.022} S_3 \\
&\qquad R = .996 \qquad D\text{—}W = 1.761
\end{aligned}
$$

Here the estimates of the parameters corresponding to the economic variables, except the one corresponding to the demand variable, were statistically significant. The same was true for parameters corresponding to seasonal variables other than S_1.

Inspection of Appendix I Table 1 further reveals, that — as a result of the intercorrelation of excess demand and productivity — the unlagged demand variable Y^d/Y^s obviously assumed the role of a productivity variable in the price equation. To shed additional light on this point, a few equations were estimated in which the lags of both the productivity variable and the demand variable were varied. The results, which are set out in Appendix I Table 2 (equations (5.11) — (5.12)), did not, however, permit definitive conclusions. The explanatory power of the productivity variable is obviously greatest when it appears as unlagged in the price equation. One further experiment was carried out to explore the part played by excess demand as a determinant of the price level. An attempt was made to supplement the picture provided by equation (5.10) by replacing $(Y^d/Y^s)_{-2}$ by another variable, h, which measured changes in the average number of hours worked (= the degree of labour utilization).[4] The empirical counterpart of this variable was formed by dividing the index of labour input by the index of employment. The result of the statistical estimation was as follows:

4. Statistical data on h were available only from 1958. Thus it was necessary to resort to extrapolation to obtain figures for 1957. For details, see Appendix III A.

$$
\begin{aligned}
(5.13)\quad ln\, p &= 1.851 + .666\, ln\, w^e - .190\, ln\, T + .126\, ln\, p^{imp}_{-2} \\
& \quad (2.036)(17.858) \qquad (2.822) \qquad (4.853) \\
& \quad - .005\, ln\, h + .003\, S_1 - .015\, S_2 + .022\, S_3 \\
& \quad (.024) \qquad (.421) \qquad (2.206) \qquad (1.723) \\
& \quad R = .996 \qquad D\text{—}W = 1.732
\end{aligned}
$$

This result hardly differs from that yielded by equation (5.10). The final choice between these two equations was therefore left to depend on the results of the analysis of the other equations in the model. A further question may, however, be raised at this point: Is the lag in the variable w^e in the price equation correctly chosen? To find an answer to this question, lags of one and two quarters were tried.

The statistical analysis carried out did not permit definitive conclusions: although the significance level of the estimate of the parameter corresponding to w^e was lower, the longer the lag, the degree of explanation did not seem to alter, no matter how the lag was chosen. To obtain additional information the observations were transformed to logarithmic differences in such a way that, in the case of each quarter of every year, the changes relative to the corresponding quarter of the preceding year were computed. The variable w^e was assumed to influence the general price level either without lag, with a lag of one quarter or with a lag of two quarters. The results were as follows:[5]

Dependent variable $\Delta\, ln\, p$

Equation	$\Delta ln\, w^e$	$\Delta ln\, w^e_{-1}$	$\Delta ln\, w^e_{-2}$	$\Delta ln\, T$	$\Delta ln\, p^{imp}_{-2}$	$\Delta ln\, h$	R	D—W
(5.14)	.710			—.247	.093	—.505	.761	1.405
	(10.867)			(2.547)	(3.332)	(1.891)		
(5.15)		.618		—.139	.133	—.338	.462	1.280
		(6.947)		(1.044)	(3.604)	(.922)		
(5.16)			.536	—.022	.160	—.096	.130	.975
			(5.680)	(.157)	(3.984)	(.242)		

These results support the hypothesis that w^e affects the general price level without a lag.

When $\Delta\, ln(Y^d/Y^s)_{-2}$ was substituted for $\Delta\, ln\, h$ in (5.14) — or, in other words, when an equation obtained from (5.10) by transformation to first differences was estimated — the result was as follows:

5. These equations were estimated with the computer of the M.I.T. For some reason, unknown to the writer, the degree of explanation obtained was somewhat higher when they were re-estimated by employing the computer of the Finnish Cable Company. However, the estimates themselves were equal. Cf. column 9 of Appendix I Table 8.

(5.17)

$$\Delta ln\, p = \underset{(11.701)}{.653\, \Delta ln\, w^{e}} - \underset{(1.873)}{.155\, \Delta ln\, T} + \underset{(2.431)}{.073\, \Delta ln\, p^{imp}_{-2}}$$
$$- \underset{(2.236)}{.173\, \Delta ln (Y^{d}/Y^{s})_{-2}} \qquad R = .956 \quad D—W = 1.553$$

The results obtained are compatible with those reported by a number of other students. Results obtained in a few previous studies are given in Table 1. For comparability, only results expressible in terms of elasticities are included in the table.

Table 1. Estimates of elasticities obtained in selected price studies[6]

	1. (5.13)	2. (5.14)	3. Klein—Ball	4. Dicks-Mireaux	5. Sargan	6. Perry	7. Bodkin
Elasticity of price level,							
with respect to wage level	.666	.710	.460	.350	.795	.466	.595
productivity	-.190	-.247	—	-.520	-.110	—	
prices of imported raw materials	.126	.093	.220	.200	.198	.344	.297
demand or degree of capacity utilization	-.005	-.505	—	—	—	-.610	.060
R^2	(.993)	.579	.992	.950	—	.921	.991

The elasticity figures yielded by the various studies are clearly similar, in the sense that the relative importance of various factors in the determination of the price level does not differ greatly from one case to another. This is so, despite the fact that the estimates are based on data for three different countries. Moreover, there are differences in coverage, in the construction of the explanatory variables and in lag patterns. Finally, the sample periods differ

6. The elasticities given in columns 2, 4 and 7 were obtained from equations estimated by transforming the variables to first differences, whereas those in the other columns are based on untransformed equations. The figures in columns 1 and 2 are results yielded by the present study and based on Finnish statistical data; those in columns 3 to 5 were estimated from data for the United Kingdom; and those in columns 6 and 7 from data for the United States. The following sources were drawn on: L. R. Klein, R. J. Ball, A. Hazlewood & P. Vandome An Econometric Model of the United Kingdom, Oxford 1961, p. 99; L. A. Dicks-Mireaux »The Interrelationship between Cost and Price Changes, 1946—1959, A Study of Inflation in Post-War Britain», *Oxf. Econ. Papers*, Oct. 1961, p. 272; J. D. Sargan »Wages and Prices in the United Kingdom: A Study in Econometric Methodology» in *Econometric Analysis for National Economic Planning*, London 1964, p. 46; G. L. Perry Unemployment, Money Wage Rates and Inflation, The M.I.T. Press 1966, p. 92; R. G. Bodkin The Wage-Price-Productivity Nexus, Philadelphia 1966, pp. 175, 185—186.

from one study to another. It is reasonable to assume that not only the estimate of the parameter corresponding to the demand variable but also other parameter estimates may be affected by cyclical fluctuations typifying the sample period. Elasticity figures estimated from quarterly data and those computed from annual data are also likely to differ;[7] and the import-price elasticity of the general price level depends on the proportion of raw-material consumption accounted for by imported raw materials.[8]

The estimates of the elasticity of the price level with respect to demand were, however, considerably at variance with one another. Therefore, a few comments are called for. The estimate obtained by PERRY is closest to the one arrived at in this study by estimating the equation in difference form. Perry interprets the variable corresponding to this elasticity figure as an indicator of the degree of capacity utilization; and since this variable describes shifts from one typical cost curve to another, it should presumably have a negative sign.[9] Perry's interpretation can also be applied in the present study: entrepreneurs were facing the declining portion of the cost curve during the sample period and, hence, the rising degree of capacity utilization enabled them to benefit from increasing returns to scale and to cut prices.

5.3. THE EARNINGS LEVEL EQUATION

The analysis of the determination of wages was based on the hypothesis (4.47) introduced in Chapter 4. The general level of earnings of wage and salary recipients, w^e, was chosen as the wage variable and the following basic model was employed as the point of departure:

7. The elasticities given in columns 4 and 7 are based on annual data. As is suggested by the figure obtained by Dicks-Mireaux, the elasticity of the price level with respect to productivity tends to be greater in absolute value if it is estimated from annual rather than from quarterly data. The same is suggested by previous computations of the present writer; see A. MOLANDER op. cit., pp. 6 and 10. Bodkin did not estimate the elasticities of the price level separately with respect to the wage level and productivity; his elasticity figure indicates the elasticity of the price level with respect to wage costs per unit of output.

8. In the two studies relating to the United States, a general index of raw material prices, rather than one of the prices of imported raw materials, was employed.

9. Perry's price equation also included a separate demand variable, and he employed changes in this variable to measure changes in the degree of capacity utilization. See G. L. PERRY op. cit., pp. 90—91. The present writer obtained in his previous studies a positive, statistically significant estimate for the parameter corresponding to the variable

(5.18) $$w^e = b_o p^{b_1} (T)^{b_2} (p^*)^{b_3} (N^d/N^s)^{b_4} e^{u_2},$$
$$b_1, b_2, b_3 > 0, b_4 < 0,$$

where p^* is a variable indicating the deviation of the cost of living index from the index of gross domestic product or that of the general price level ($p^* = p^e/p$, where p^e = the cost of living index); N^d = the demand for labour and N^s = the supply of labour, so that N^d/N^s = excess demand for labour; and u_2 = the error term. The result obtained by estimating (5.18) was

(5.19) $$\begin{aligned} ln\, w^e = &-2.642 + \underset{(20.943)}{1.690}\, ln\, p - \underset{(.162)}{.017}\, ln\, T + \underset{(6.599)}{1.026}\, ln\, p^* \\ &+ \underset{(4.160)}{2.898}\, ln(N^d/N^s) + \underset{(2.811)}{.029}\, S_1 + \underset{(1.777)}{.012}\, S_2 - \underset{(1.613)}{.012}\, S_3 \\ &R = .998 \qquad D\text{—}W = 1.014 \end{aligned}$$

It should be pointed out, first of all, that the value of the test variable D—W was low, suggesting the presence of autocorrelation between the residual terms. A more notable feature of the estimated equation is, however, that the parameter estimates corresponding to the excess demand and productivity variables had «wrong» signs. The latter estimate did not, however, differ significantly from zero. To find out whether these results were due to interdependences between the explanatory variables, the influence on these parameter estimates of the specification of the lag in the price variable was first considered, by assuming that the lag was either one or two quarters. As appears from Appendix I Table 3 (equations (5.20) and (5.21)), however, the results did not alter the picture given by equation (5.19). Yet the statistical significance of the parameter corresponding to the price variable was found to be greatest when this variable was in unlagged form. Following this, some experiments were carried out in which the lags of the productivity and demand for labour variables were varied. The results are set out in Appendix I Tables 4 and 5 (equations (5.22)—(5.25)).

The signs of the parameter estimates corresponding to the productivity and excess demand variables remained, however, incompatible with the *a priori* assumptions, no matter how the lag of the former was specified. On the other hand, when the lag in the latter variable was increased, statistically significant

Y^d/Y^s when the sample period consisted of the years 1957—1962. This period, except for its closing years, was characterized by a very strong cyclical upswing; see, e.g., A. Molander »Interdependence between Prices and Wages», *KAK* No. 3, 1968. It should also be stated that, when equation (5.13) was estimated from data for 1958—1966, a positive estimate significantly different from zero was obtained for the parameter corresponding to the variable h. The estimate of the parameter corresponding to the import price variable had a negative sign, but it did not differ significantly from zero.

estimates of the parameter corresponding to the productivity variable were obtained, their signs being now consistent with the *a priori* assumption. Obviously, therefore, the parameter estimates corresponding to the productivity and excess demand for labour variables were distorted when both were simultaneously included in the earnings level equation.

By substituting the variable h for N^d/N^s it was considered possible to avoid this distortion of parameter values resulting from multicollinearity.[10]

When N^d/N^s was replaced by h in (5.19), the estimation result was as follows:[11]

$$
\begin{aligned}
(5.26) \qquad ln\, w^e = & -5.928 + \underset{(18.767)}{1.297}\, ln\, p + \underset{(4.791)}{.358}\, ln\, T + \underset{(5.071)}{.834}\, ln\, p^* \\
& \;\;(5.210) \\
& + \underset{(2.453)}{.632}\, ln\, h + \underset{(.474)}{.004}\, S_1 + \underset{(3.668)}{.033}\, S_2 + \underset{(1.353)}{.025}\, S_3 \\
& R = .997 \qquad D\text{—}W = .809
\end{aligned}
$$

In this case all estimates of parameters corresponding to economic variables differed significantly from zero and their signs were consistent with the assumptions advanced. On the other hand, the low value of the D—W test variable suggests that the residual terms were still autocorrelated.

To discover whether there is likely to be a lag between changes in the price level and those in the level of earnings, transformation to logarithmic differences was resorted to. The results of estimation obtained with the unlagged values and with values lagged one quarter and two quarters respectively were as follows:[12]

Dependent variable $ln\, w^e$

Equation	$\Delta ln\, p$	$\Delta ln\, p_{-1}$	$\Delta ln\, p_{-2}$	$\Delta ln\, T$	$\Delta ln\, p^*$	$\Delta ln\, h$	R	D—W
(5.27)	1.078			.526	.389	.977	.758	1.024
	(13.314)			(6.130)	(2.558)	(3.391)		
(5.28)		1.079		.488	.457	.981	.667	1.465
		(11.431)		(4.847)	(2.711)	(2.969)		
(5.29)			1.112	.400	.514	1.095	.489	1.519
			(9.224)	(3.105)	(2.680)	(2.815)		

10. The coefficient of correlation between $ln\, T$ and $ln\, (N^d/N^s)$ was .520, whereas $ln\, T$ and $ln\, h$ correlated only to the extent of .195.

11. It should be recollected that, as was argued in the preceding chapter, h is a decreasing function of N^d/N^s. Hence, as the wage level was assumed to be a decreasing function of N^d/N^s, it is an increasing function of h.

12. The lag assigned to $\Delta\, ln\, p^*$ was in each case the same as that assigned to $\Delta\, ln\, p$.

This experiment also supports the hypothesis that p affects w^e without a lag.[13]

The results of the estimation of the transformed equations corresponding to (5.19) and (5.22) were as follows:

$$(5.30) \quad \Delta ln\, w^e = .011 + \underset{(6.306)}{1.210}\, \Delta\, ln\, p + \underset{(.876)}{.111}\, \Delta\, ln\, T + \underset{(3.308)}{.540}\, \Delta\, ln\, p^* + \underset{(2.755)}{1.932}\, \Delta\, ln\, (N^d/N^s) \qquad R = .726 \qquad D\text{—}W = .870$$

$$(5.31) \quad \Delta\, ln\, w^e = .015 + \underset{(7.208)}{1.114}\, \Delta\, ln\, p + \underset{(1.607)}{.171}\, \Delta\, ln\, T + \underset{(3.336)}{.484}\, \Delta\, ln\, p^* + \underset{(3.716)}{1.318}\, \Delta\, ln\, (N^d/N^s)_{-1} \qquad R = .770 \qquad D\text{—}W = .851$$

The results show that the correlation between T and N^d/N^s persisted even after transformation to first differences ($\Delta\, ln\, T$ and $\Delta\, ln\, N^d/N^s$ correlated .393); in consequence, the coefficient of $\Delta\, ln\, T$ did not differ very significantly from zero.

It is difficult to find support for the above results in studies conducted elsewhere, since most of these have followed the lines blazed by Phillips and analyzed the dependence of changes in the wage level on the level of excess demand for labour. Selected estimates of the elasticity of the wage level with respect to the price level, and with respect to the productivity of labour in cases where such have been available, are, however, given in Table 2.[14]

13. It is of some interest to note at this point that estimates greater than unity were obtained for the price-level elasticity of earnings level, though these did not differ significantly from 1. This suggests, however, that during the period under study there was a tendency for changes in the level of earnings to »overcompensate» those in the price level. When attempts are made later in this study to explain changes in the level of negotiated wage rates in terms of changes in the price level, elasticities smaller than unity are obtained. In other words, there was a tendency for negotiated wage changes to undercompensate price changes.

14. The elasticities in columns 1 and 6 are based on results of untransformed equations, whereas those in the other columns are based on equations transformed to first differences. The figures in columns 1 and 2 are results of the present study and estimated from Finnish data; those in columns 3 and 4 are based on data for the United Kingdom and those in columns 5 and 6 on data for the United States. The following sources were used: L. R. Klein, R. J. Ball, A. Hazlewood & P. Vandome op. cit., p. 115; L. A. Dicks-Mireaux op. cit., p. 217; G. L. Perry op. cit., p. 92; and R. G. Bodkin op. cit., pp. 146—148.

Table 2. Estimates of elasticities obtained in selected wage studies

	1. (5.26)	2. (5.27)	3. Klein–Ball	4. Dicks-Mireaux	5. Perry	6. Bodkin
Elasticity of wage level,[15] with respect to						
price level	1.297	1.079	.821	.410	.367	.969
productivity	.358	.526	—	—	—	.312
R^2	.994	.575	—	.910	.870	.845

The estimates obtained by BODKIN seem to agree best with those arrived at in the present study. Those obtained by KLEIN's group did not, however, differ greatly either from Bodkin's or from the present writer's estimates.[16] On the other hand, the elasticities reported in the other two studies (those of DICKS-MIREAUX and PERRY) are considerably lower.

When the order of magnitude of the above elasticity figures is considered, the fact of whether or not the possible influence of the productivity of labour was also attended to should be taken into account. The price-level elasticity of the wage level obtained by Bodkin was less than unity, but the result is not open to objection, because the elasticity of the wage level with respect to productivity was separately estimated. On the other hand, in the remaining three previous studies the influence of productivity was not taken into consideration; hence, according to them, real wages may decline as the price level rises, even if the productivity of labour is simultaneously increasing.[17]

5.4. THE ACTIVITY EQUATION

When price and wage equations were constructed, it was found possible to improve the properties of the model by replacing the commodity and labour demand variables by a single variable describing variations in the average

15. The elasticity estimate obtained by Klein and his associates (column 3) relates to wage rates. All the others are elasticities of the level of earnings.

16. The estimate in column 3 is most nearly comparable to the estimate of the price-level elasticity of negotiated wage rates that will be presented in Section 5.6; this estimate is .867.

17. When hypotheses were derived for this study in Chapter 4, the assumption was advanced that the elasticities of the wage level with respect to the price level and productivity are likely to equal unity at least in the long run. The writer's previous studies based on annual data have, in fact, resulted in estimates of the elasticity of the wage level with respect to productivity that have not differed significantly from unity; see A. MOLANDER op. cit., p.7.

number of hours worked. A necessary condition for such a replacement was found to be, however, that an equation can be constructed which represents the new common demand variable as a function of the original demand variables. In the tentative experiments carried out, the productivity variable occurred in the equation as a further explanatory variable. Thus, the point of departure was the following basic equation:

$$(5.32)\quad \ln h = f_o (N^d/N^s)^{f_1} (Y^d/Y^s)^{f_2}_{-2}\, T^{f_3} e^{u_5},\quad f_1 < 0,\ f_2, f_3 > 0.$$

The result of estimation was as follows:

$$(5.33)\quad \ln h = 4.132 - \underset{(3.047)}{1.386}\ \ln (N^d/N^s) + \underset{(4.346)}{.313}\ \ln (Y^d/Y^s)_{-2}$$
$$+ \underset{(5.480)}{.111}\ \ln T - \underset{(5.274)}{.035}\ S_1 - \underset{(3.689)}{.017}\ S_2 - \underset{(14.445)}{.068}\ S_3$$
$$R = .930 \qquad D\text{—}W = 1.365$$

All the parameter estimates differed significantly from zero and had signs consistent with the *a priori* assumptions. When the variables in the basic equation (5.32) were transformed to first differences, the productivity variable lost its explanatory power.[18] The parameter estimates obtained by omitting the productivity variable were

$$(5.34)\quad \Delta \ln h = - \underset{(3.055)}{.836}\ \Delta \ln(N^d/N^s) + \underset{(4.276)}{.214}\ \Delta \ln(Y^d/Y^s)_{-2}$$
$$R = .567 \qquad D\text{—}W = 1.281$$

5.5. A NOTE ON WAGE DRIFT

The determination of prices and wages was considered in the foregoing sections in terms of certain explanatory models. Analysis of these models did not, however, suggest the existence of lags between prices and wages. With a view to examining the dynamic properties of the model, lags would have been desirable; and preliminary experiments suggested in fact that, if the earnings level equation is replaced by one describing variations in negotiated wage rates, there seems to be a lag of one quarter between wages and

18. The following parameter estimates were obtained:

$$(5.35)\quad \Delta \ln h = - \underset{(2.825)}{.892}\ \Delta \ln(N^d/N^s) + \underset{(4.156)}{.219}\ \Delta \ln(Y^d/Y^s)_{-2} + \underset{(.369)}{.014}\ \Delta \ln T$$
$$R = .589 \quad D\text{—}W = 1.155$$

prices. The »wage drift» concept, defined here as the ratio between the level of earnings and the level of negotiated wage rates, or as the logarithmic difference between these two, made it possible to relate the first to the second. In symbols

$$(5.36)\quad ln\, w^e - ln\, w^r = \text{wage drift},$$

where w^e = the general level of earnings and w^r = the level of negotiated wage rates. Conversely, if wage drift and the level of wage rates are known, the level of earnings can be obtained by finding the sum of the logarithms of these two. Finnish statistics do not, however, contain sufficient data for determining movements in the general level of negotiated wage rates. Thus it was necessary to construct a special index for the purpose, based on the available information concerning collective wage agreements. As this data was deficient, it was necessary to accept an indicator which reflected the movement of negotiated wage rates in certain key sectors only.[19]

Since both components of the earnings level are endogenous, it is necessary for us to have an equation explaining variations in wage drift. In the next section, however, the determination of negotiated wage rates is first analyzed by means of an empirical explanatory equation.

5.6. THE NEGOTIATED WAGE RATES EQUATION

In the construction of this equation, the information provided by the analysis of the earnings level equation was employed. The question of greatest interest here was that concerning the length of the lag between negotiated wage rates and the price level. To elucidate this point, negotiated wage rates were assumed to react to price changes either without a lag, with a lag of one quarter or with a lag of two quarters. The specifications of the equations to be estimated were identical to those applied in the case of equations (5.27)—(5.29), except that the dependent variable was $\Delta\, ln\, w^r$ instead of $\Delta\, ln\, w^e$. The following estimates were obtained.[20]

19. For details, see Appendix III A.
20. In each case, the lag in $\Delta\, ln\, p^*$ is of the same length as that in $\Delta\, ln\, p$.

Dependent variable $\Delta\ ln\ w^r$

Equation	$\Delta\ ln\ p$	$\Delta\ ln\ p_{-1}$	$\Delta\ ln\ p_{-2}$	$\Delta\ ln\ T$	$\Delta\ p^*$	$\Delta\ ln\ h$	R	$D—W$
(5.37)	.808			.328	.486	.450	.743	1.399
	(11.907)			(4.557)	(3.811)	(1.863)		
(5.38)		.833		.287	.655	.448	.819	2.064
		(14.035)		(4.545)	(6.176)	(2.154)		
(5.39)			.867	.220	.623	.544	.764	2.180
			(11.896)	(2.826)	(5.366)	(2.314)		

The parameter corresponding to the price variable seems to differ most significantly from zero when the lag in this variable is specified as one quarter. A similar observation applies to the coefficient of multiple correlation.

When equation (5.38) was estimated in its original form, the result was as follows:

$$(5.40)\quad ln\ w^r = -\ 2.897 + .932\ ln\ p_{-1} + .211\ ln\ T + .916\ ln\ p^*_{-1}$$
$$\qquad (4.168)(20.084)\qquad (4.116)\qquad (8.781)$$
$$+ .487\ ln\ h + .020\ S_1 + .028\ S_2 + .029\ S_3$$
$$(3.092)\qquad (3.229)\qquad (4.817)\qquad (2.706)$$
$$R = .998 \qquad D—W = 2.001$$

A comparison of the wage rate equation (5.40) and the earnings level equation (5.26) leads to certain observations of some interest. The degree of explanation is approximately the same in both cases, and so is the relative importance of the various independent variables. On the other hand, the parameter estimates are, without exception, somewhat smaller in the first than in the second equation.[21]

5.7. THE WAGE DRIFT EQUATION

The amount of wage drift is quite generally regarded as an indicator of economic activity or, more specifically, as an indicator of demand in the labour market.[22] Wages actually paid tend to exceed negotiated wage rates more definitely in excess demand than in excess supply situations. When

21. Cf. also the parameter estimates obtained for the wage rate equations corresponding to equations (5.19), (5.23), (5.30) and (5.31), which are set out in Appendix I Tables 6 and 7 (equations (5.38) — (5.41)).

22. See, e.g., L. R. Klein, R. J. Ball, A. Hazlewood & P. Vandome op. cit., p. 120.

an attempt is made to find an empirical explanation for wage drift, it is therefore natural to employ other indicators of variations in demand as independent variables. B. Hansen's and G. Rehn's study, published in 1956, may be regarded as a pioneer work in the investigation of wage drift.[23] The authors hypothesized that excess demand for labour, »excess profits» and productivity are likely to be among the determinants of wage drift. However, only the parameter estimate corresponding to the excess demand variable was significantly different from zero.[24] By contrast, Klein and his associates arrived at statistically significant estimates not only for their demand variable but also for their productivity variable.[25]

The model selected here as the starting point was specified like the one used by Klein and his associates, except for its mathematical form, which was as follows:

$$(5.45) \quad w^e/w^r = g_o\, h^{g_1} T^{g_2} e^{u_4}, \quad g_1, g_2 > 0.$$

The equation was estimated both in its original form and after transforming the variables to first differences. The results were respectively as follows:

$$(5.46) \quad \ln w^e/w^r = -7.014 + \underset{(3.840)}{1.011} \ln h + \underset{(15.662)}{.508} \ln T - \underset{(2.276)}{.022} S_1 + \underset{(2.206)}{.022} S_2 + \underset{(2.288)}{.044} S_3 \qquad R = .962 \qquad D\text{—}W = .938$$

$$(5.47) \quad \Delta \ln(w^e/w^r) = \underset{(3.267)}{.845} \Delta \ln h + \underset{(6.191)}{.378} \Delta \ln T \qquad R = .745 \qquad D\text{—}W = .947$$

The estimates of the parameters corresponding to the two explanatory variables differed significantly from zero, irrespective of whether the equation was estimated in untransformed or transformed form.[26]

23. See B. Hansen & G. Rehn »On Wage-Drift, A Problem of Money-Wage Dynamics» in *25 Economic Essays in Honour of Erik Lindahl*, Stockholm 1956.

24. The same result was arrived at in a recently published study concerning the Swedish labour market; see L. Jacobsson & A. Lindbeck »Labor Market Conditions, Wages and Inflation — Swedish Experiences 1955—67», a paper presented at the Amsterdam Meeting of the Econometric Society in September 1968.

25. See L. R. Klein, R. J. Ball, A. Hazlewood & P. Vandome op. cit., pp.107—108.

26. In the study of Klein and his associates, the productivity variable failed to contribute significantly to the explanation of wage drift when the variables were transformed to first differences. This was also the case in the present study when a constant term, designed to represent the trend clearly apparent in the time series measuring wage drift,

Various arguments can be put forward in support of the choice of independent variables. The average number of hours worked is a very sensitive cyclical indicator, and this makes its inclusion as an explanatory variable in the wage drift equation reasonable. Average hourly earnings may also vary as a result of variations in the amount of overtime worked. This also makes the inclusion of an indicator of the degree of labour utilization in a wage drift equation well-founded.

The inclusion of a productivity variable in the wage drift equation also seems natural for a variety of reasons. First, productivity can be taken as a sensitive indicator of economic activity, which is likely to influence wages via the demand factors discussed previously. Secondly, the earnings of pieceworkers per unit of time are likely to rise as a result of technical progress, even when the rates remain unchanged.[27]

Wage drift can also be considered as an adjustment phenomenon. If there is excess demand in the labour market, wage drift can be expected to occur, since entrepreneurs have then to compete with one another for the scarce labour force. They may be unable to hire additional workers, except at rates exceeding the negotiated ones. Therefore, wage drift is an increasing function of excess demand for labour. When wage drift was considered as an adjustment phenomenon, the following basic equation was chosen as the point of departure:[28]

$$(5.48) \qquad w^e/w^r = g_o h^{g_1} (N^d/N^s)^{g_3} e^{u_4}, \qquad g_1, g_3 > 0.$$

The result obtained by estimating this equation in its original form was

$$(5.49) \qquad \underset{}{ln\, w^e/w^r} = -12.691 + \underset{(4.676)}{2.743\, ln\, h} + \underset{(3.024)}{4.124\, ln(N^d/N^s)} + \underset{(1.593)}{.038\, S_1} + \underset{(1.539)}{.040\, S_2} + \underset{(3.423)}{.152\, S_3} \qquad R = .723 \qquad D\text{—}W = .623$$

was introduced into equation (5.47). Obviously, the productivity variable assumed the role of a trend variable in (5.47). Cf. L. R. KLEIN, R. J. BALL, A. HAZLEWOOD & P. VANDOME op. cit., p. 108.

27. Cf. L. R. KLEIN, R. J. BALL, A. HAZLEWOOD & P. VANDOME op. cit., p. 77.

28. The interdependence of T and N^d/N^s affected the parameter estimates so strongly in this instance, too, that exclusion of the productivity variable was found to be imperative when the adjustment model was applied. It should be pointed out that an effort will be made here to separate out the influence of the demand situation without resorting to roundabout methods. The variable N^d/N^s will then measure the effect of excess demand on wage drift. The variable h is designed to measure only those effects that variations in overtime exert on the difference between earnings and wage rates.

When this equation was estimated after transforming the variables to first differences, inclusion of an explicit trend factor was found advisable, in order to account for the trend distinctly shown by the time series describing wage drift. The result was as follows:

$$(5.50) \qquad \Delta ln\ w^e/w^r = .020 + \underset{(1.871)}{.371}\ \Delta ln\ h + \underset{(2.152)}{.713}\ \Delta ln(N^d/N^s)$$

$$R = .359 \qquad D\text{—}W = .970$$

The results obtained by following the adjustment approach were definitely inferior to those arrived at by employing the basic equation (5.45).

5.8. THE DEMAND FOR LABOUR EQUATION

In Chapter 4, the demand for labour was initially assumed to depend on the volume of output and the real wage level. Thus, our starting point here is the following basic equation:

$$(5.51) \qquad N^d = c_o Y^{c_1} (w^e/p)^{c_2} e^{u_6}. \qquad c_1 > 0,\ c_2 < 0.$$

The result of estimation was

$$(5.52) \qquad ln\ N^d = 1.695 + \underset{(6.419)}{.226}\ ln\ Y - \underset{(1.197)}{.075}\ ln(w^e/p)$$

$$- \underset{(3.000)}{.005}\ S_1 + \underset{(5.696)}{.010}\ S_2 + \underset{(8.415)}{.016}\ S_3$$

$$R = .968 \qquad D\text{—}W = 1.288$$

Thus, a comparatively high degree of explanation was attained. The parameter corresponding to the relative-price variable did not, however, differ significantly from zero, although its sign was consistent with the advance assumption.

In Chapter 4 it was also argued that variations in productivity may alter the relationship between the demand for labour and output. This can be accounted for by including a variable measuring variations in the productivity of labour as an additional independent variable in the equation, to obtain

$$(5.53) \qquad N^d = c_o Y^{c_1} (w^e/p)^{c_2} T^{c_3} e^{u_6}, \qquad c_3 < 0.$$

One difficulty associated with the construction of the productivity variable should briefly be discussed at this point. Attempts have sometimes been made to measure the productivity of labour by the ratio of output to employment. However, had this procedure been applied here, equation (5.53) would have become definitional in nature. To avoid this pitfall, the ratio between output and total labour input was used as a measure of productivity. This measure was feasible here, as changes in labour input clearly differ from those in employment.

The estimate obtained was

$$(5.54) \quad \begin{aligned} \ln N^d = {} & \underset{(19.496)}{3.887} + \underset{(4.736)}{.462} \ln Y - \underset{(1.360)}{.080} \ln w^e/p \\ & - \underset{(2.567)}{.309} \ln T - \underset{(.829)}{.004}\, S_1 + \underset{(5.930)}{.023}\, S_2 + \underset{(8.790)}{.044}\, S_3 \\ & R = .976 \qquad D\text{—}W = 1.591 \end{aligned}$$

The estimate of the coefficient of the productivity of labour variable differed significantly from zero and had a sign consistent with the *a priori* assumption.

An even higher degree of explanation was achieved when the relative-price variable was split up into its two components. In this case, however, the signs of the parameter estimates corresponding to these components could not be given any economically meaningful interpretation. Nor did the estimates differ significantly from zero. The distortion of parameter estimates was a typical multicollinearity phenomenon, for the correlation between p and w^e was as high as .990. The result of estimation was

$$(5.55) \quad \begin{aligned} \ln N^d = {} & \underset{(19.992)}{4.114} + \underset{(5.128)}{.465} \ln Y - \underset{(1.065)}{.093} \ln p + \underset{(.084)}{.005} \ln w^e \\ & - \underset{(2.429)}{.274} \ln T - \underset{(1.425)}{.007}\, S_1 + \underset{(5.850)}{.022}\, S_2 + \underset{(9.712)}{.046}\, S_3 \\ & R = .980 \qquad D\text{—}W = 1.834 \end{aligned}$$

When the variables in equation (5.53) were transformed to first differences, estimation yielded

$$(5.56) \quad \begin{aligned} \Delta \ln N^d = {} & \underset{(6.775)}{.536}\, \Delta \ln Y - \underset{(1.578)}{.094}\, \Delta \ln w^e/p - \underset{(4.377)}{.371}\, \Delta \ln T \\ & R = .822 \qquad D\text{—}W = 1.338 \end{aligned}$$

5. 9. THE SUPPLY OF LABOUR EQUATION

In Chapter 4 the supply of labour was assumed to depend not only on the population of working age but also on relative prices and a certain attitude variable. It was presumed that a variable indicating excess demand for commodities could be selected as the attitude variable. Thus, we have to start from the following basic equation:

$$(5.57) \qquad N^s = d_o V^{d_1}(w^e/p)^{d_2}(Y^d/Y^s)^{d_3}_{-2}\, e^{u_7} \qquad d_1, d_2 > 0,$$

where the new variable, V, is the population of working age. The result of estimation was

$$(5.58) \qquad \begin{aligned} ln\, N^s &= \underset{(2.832)}{2.242} + \underset{(2.971)}{.511}\, ln\, V + \underset{(.304)}{.026}\, ln(w^e/p) + \underset{(2.090)}{.107}\, ln(Y^d/Y^s)_{-2} \\ &\quad - \underset{(1.261)}{.006}\, S_1 + \underset{(4.230)}{.019}\, S_2 + \underset{(8.229)}{.036}\, S_3 \\ &\qquad R = .962 \qquad D\text{—}W = 1.451 \end{aligned}$$

The result can be considered satisfactory, except for the estimate of the parameter corresponding to the variable $ln\ w^e/p$. As was to be expected, the decomposition of $ln\ w^e/p$ did not improve the situation in this case either; the result was

$$(5.59) \qquad \begin{aligned} ln\, N^s &= \underset{(.340)}{.424} + \underset{(2.903)}{.992}\, ln\, V - \underset{(.092)}{.010}\, ln\, p - \underset{(.935)}{.077}\, ln\, w^e \\ &\quad + \underset{(2.515)}{.149}\, ln(Y^d/Y^s)_{-2} - \underset{(1.200)}{.005}\, S_1 + \underset{(5.310)}{.021}\, S_2 + \underset{(7.568)}{.036}\, S_3 \\ &\qquad R = .971 \qquad D\text{—}W = 1.551 \end{aligned}$$

The result of the estimation of (5.57) after transformation to first differences was as follows:

$$(5.60) \qquad \begin{aligned} \Delta ln\, N^s &= \underset{(4.331)}{.700}\, \Delta ln\, V - \underset{(1.005)}{.067}\, \Delta ln(w^e/p) + \underset{(3.130)}{.123}\, \Delta ln(Y^d/Y^s)_{-2} \\ &\qquad R = .454 \qquad D\text{—}W = 1.239 \end{aligned}$$

The sign of the estimate of the coefficient of the attitude variable was positive in both the untransformed and transformed equation. Yet, transformation to first differences seemed to reduce the degree of explanation quite considerably, although all the parameter estimates differed more significantly from zero than in the untransformed case. It should be noted, however, that the estimate of the coefficient of the price-wage variable did not have a sign consistent with the *a priori* assumption.[29]

29. Yet, when the model was estimated simultaneously, an estimate with a sign consisted with the assumption emerged; see Appendix I Table 14.

5.10. A SUMMARY OF THE PARTIAL SINGLE-EQUATION ANALYSIS

Some distinctive features of the line of approach followed in the foregoing analysis should still be emphasized at this point. The criteria against which the »goodness» of the various equations was appraised included not only the relevant coefficient of multiple correlation but also, as usual, the statistical significance of the estimates obtained for the parameters and the compatibility of the signs of the estimates with the *a priori* assumptions advanced. It should be pointed out, however, that some of the results that failed to meet the last-mentioned criterion may still be economically reasonable, provided that other assumptions concerning the signs, different from those introduced in this study, are also justifiable.

An effort was made to keep the number of variables, and the number of mathematical operations applied to the variables, as small as possible. This principle was adopted, because the »manageability» of the system decreases as hte number of variables increases, and manipulation of the variables (e.g., the use of moving averages) complicates the analysis of the implications of the system.

The number of experiments undertaken in the analysis of any one equation does not reflect the relative importance attached to it. Rather, it indicates the degree of difficulty in arriving at a satisfactory structure. The price and wage equations proved to be the most difficult in this respect.

6. SIMULTANEOUS ANALYSIS

6.1. COMBINED HYPOTHESES AND SIMULTANEOUS ESTIMATION

The foregoing partial analysis revealed, in particular, that the influence of excess demand on the wage level was difficult to separate out by a direct method. The application of an indirect method, again, presupposes the construction of a simultaneous model. The results of partial analysis are, however, compatible with a variety of interpretations. It is essential, therefore, to select the relationships to be included in the simultaneous model in such a way that they are mutually consistent and form a logical whole.

The model to be estimated simultaneously was chosen as follows:

$$p = a_o(w^e)^{a_1}(T)^{a_2}(p^{imp})^{a_3}_{-2}\, h^{a_4}e^{u_1}, \qquad a_1, a_3 > 0, \quad a_2, a_4 < 0 \tag{6.1}$$

$$w^r = b_o(p)^{b_1}_{-1}(T)^{b_2}(p^*)^{b_3}_{-1}h^{b_4}e^{u_2}, \qquad b_1, b_2, b_3, b_4 > 0 \tag{6.2}$$

$$w^e/w^r = g_o h^{g_1}(N^d/N^s)^{g_2}e^{u_3}, \qquad g_1, g_2 > 0 \tag{6.3}$$

$$h = f_o(N^d/N^s)^{f_1}(Y^d Y^s)^{f_2}_{-2}\, e^{u_4}, \qquad f_1 < 0, \quad f_2 > 0 \tag{6.4}$$

$$N^d = c_o\, Y^{c_1}(w^e/p)^{c_2}(T)^{c_3}e^{u_5}, \qquad c_1 > 0, \quad c_2, c_3 < 0 \tag{6.5}$$

$$N^s = d_o V^{d_1}(w^e/p)^{d_2}(Y^d/Y^s)^{d_3}_{-2}e^{u_6}, \qquad d_1, d_2, d_3 > 0 \tag{6.6}$$

It includes six endogenous variables, six exogenous variables and one lagged endogenous variable:

Endogenous variables:	Exogenous variables:
p, w^e, w^r, h, N^d, N^s	T, p^{imp}_{-2}, $(Y^d/Y^s)_{-2}$, Y, V, p^*_{-1}

Lagged endogenous variable: p_{-1}

If the variable h were endogenized, it would be possible to split the productivity variable into an endogenous and an exogenous component; this is because h was constructed by dividing the volume of labour input N^e by the employment of wage and salary earners. The latter variable, again, is an operational counterpart of N^d. Since N^d and N^e/N^d are endogenous, N^e is also endogenous. The productivity variable was obtained through dividing the volume of output, Y, by the labour input N^e. On the other hand, the indicator of productivity thus obtained is merely an operational counterpart of a theoretical concept which is, as a matter of fact, logically independent of these two variables. It was considered appropriate, therefore, to allow T to remain exogenous in this model.

In the system consisting of equations (6.1)—(6.6) the level of earnings was split up into two components principally because this procedure makes possible an analysis of the dynamic properties of the system. It will be of interest to examine, for the sake of comparison, whether the properties of this system differ appreciably from those of a system where the wage rate and wage drift equations, i.e., equations (6.2) and (6.3), are replaced by the earnings level equation

$$(6.7) \qquad w^e = b_o p^{b_1} (T)^{b_2} (p^*)^{b_3} h^{b_4} e^{u_2}, \quad b_1, b_2, b_3, b_4 > 0$$

The system comprising equations (6.1)—(6.6) will be termed Excess Demand Model I and that consisting of equations (6.1), (6.7) and (6.4)—(6.6) Excess Demand Model II. The vector of exogenous variables in the latter model includes p^* in place of p^*_{-1}.

Because the partial analysis suggested the possibility of alternative interpretations, consideration of yet another model — which may appropriately be termed a capacity model — was regarded as warranted. The single-equation approach yielded parameter estimates corresponding to N^d/N^s with a positive sign. A positive sign was not, however, compatible with the excess demand hypothesis introduced in this study which was based on a disequilibrium approach. It may be reasonable to suppose, on the other hand, that N^d/N^s assumed the role of a capacity variable in the wage equations and, in consequence, took a positive sign. A reasonable assumption in the case of the wage equation is that, under conditions of full employment, efforts to increase the degree of labour utilization will be successful only if overtime or piece-work resulting in higher than average earnings can be increased. In the price equation, by contrast, the capacity variable can be supposed to measure those influences that will occur when the average costs of production can be reduced by increasing the degree of capacity utilization; i.e., it can be assumed to describe shifts from one typical cost curve to another, each of which is below the preceding one. No »activity equation» is necessary in such a model, and h assumes an exogenous role.

Capacity Model I, corresponding to the Excess Demand Model I, can be written

$$(6.8) \qquad p = a_o (w^e)^{a_1} T^{a_2} (p^{imp})^{a_3}_{-2} (Y^d/Y^s)^{a_4}_{-2} e^{u_1}, \qquad a_1, a_3 > 0, \quad a_2, a_4 < 0$$

$$(6.9) \qquad w^r = b_o p^{b_1}_{-1} T^{b_2} (p^*)^{b_3}_{-2} (N^d/N^s)^{b_4}_{-1} e^{u_2}, \qquad b_1, b_2, b_3, b_4 > 0$$

$$(6.10) \qquad w^e/w^r = g_o h^{g_1} (N^d/N^s)^{g_2} e^{u_3}, \qquad g_1, g_2 > 0$$

$$(6.11) \qquad N^d = c_o Y^{c_1}(w^e/p)^{c_2} T^{c_3} e^{u_4} \qquad c_1 > 0, \; c_2, c_3 < 0$$

$$(6.12) \qquad N^s = d_o V^{d_1}(w^e/p)^{d_2}(Y^d/Y^s)^{d_3}_{-2} e^{u_5} \qquad d_1, d_2, d_3 > 0$$

Capacity Model II was obtained from this through replacing (6.9) and (6.10) by the equation

$$(6.13) \qquad w^e = b_o p^{b_1}(T)^{b_2}(p^*)^{b_3}(N^d/N^s)^{b_4}_{-1} e^{u_2}, \qquad b_1, b_2, b_3, b_4 > 0$$

The choice of the estimation method to be applied to a model depends essentially on whether all the equations in the model are identified or not.[1] Employing the order criterion it is easily seen that all the equations of both the excess demand and the capacity models are overidentified. In the case of multi-equation models of this kind, the method of two-stage least squares has proved a feasible procedure. It also compares favourably with other system-of-equations methods on account of its simplicity. When this method is employed, the model is first transformed to reduced form and the parameters of the reduced form are estimated. Thus, an estimate of each endogenous variable is obtained. These estimates, from which the stochastic components were eliminated during the first stage of the analysis, will then be substituted for the endogenous variables occurring as independent variables in the structural form, and the parameters of the structural form are estimated. A particular variant of this method was applied in the estimation of Excess Demand Model I and Capacity Model I. The lagged value p_{-1} of the variable p occurs in these models. Since p and p_{-1} are strongly intercorrelated, p_{-1} is also likely to correlate with the residual terms of the models. Therefore, when p_{-1} is involved in the vector of independent variables, the first-stage estimates may be distorted. This complication can be avoided, however, by excluding p_{-1} from the vector of independent variables during the first stage and by considering it as an ordinary predetermined variable during the second stage. What is concerned is, in fact, a method of instrumental variables, in which all the exogenous variables of the model but none of the lagged endogenous variables are among the instruments.[2] A similar pro-

1. For identification, see, e.g., T. C. Koopmans & Wm. C. Hood »The Estimation of Simultaneous Linear Economic Relationships» in *Studies in Econometric Method,* ed. Wm. C. Hood & T. C. Koopmans, Cowles Commission Monographs No. 14, New York —London 1953.

2. This method is based on ideas put forward by Professor F. M. Fisher in his lectures at the Massachusetts Institute of Technology.

cedure is warranted in the case of the variable $(N^d/N^s)_{-1}$, which is involved in Capacity Models I and II.

Each model was estimated both in its original form and after transforming the variables to first differences. The results of the calculations are set out in Appendix I Tables 8—14. The time paths of the dependent variables of the transformed Excess Demand Model I, those of the independent variables as estimated from the model, of the contributions of the independent variables to the total explanation and of the residual errors are represented graphically in Figures 6—11 (Appendix II).

The influence of the simultaneous equation method appears most clearly from the estimates of the transformed models. The coefficients of determination were, almost without exception, lower than those obtained through the ordinary method of least squares. Coefficients of determination higher than or approximately equal to those yielded by the single-equation method were obtained for the wage drift and the demand for labour equations. The parameter values did not differ greatly from those obtained by the ordinary least-squares technique.

A simultaneous estimation method has, however, certain advantages in the selection of a multi-equation model suitable for further analysis. The logic inherent in the model, considered as a whole, can better be revealed by a simultaneous estimation method. The untransformed Excess Demand Model I and Capacity Model I, for example, are found not to provide an appropriate basis for further analysis, since the net effect of N^d/N^s in the wage drift equation is negative (when the interdependence between h and N^d/N^s created by the activity equation is taken into account), even though it should be positive according to the *a priori* assumption introduced. On the other hand, when the two models were estimated by transforming all the variables into first differences, the net effect proved to be positive. The transformed Capasity Models I and II were not found to be appropriate either, since the inclusion of h in the vector of independent variables during the first stage obviously led to a distortion of the estimate obtained for the parameter corresponding to w^e/p in the demand for labour equation. Moreover, when the two capacity models were estimated by transforming the variables to first differences, the sign of this parameter in the supply of labour function was inconsistent with the assumption advanced. Thus, the only models suitable for the purposes of further analysis were the untransformed Excess Demand Model II and Capacity Model II and the transformed Excess Demand Models I and II.

6.2. ON THE DYNAMIC PROPERTIES OF THE INFLATIONARY PROCESS

The foregoing considerations have been in the nature of partial analysis. Although the system dealt with consisted of several equations, interest was focused on the structure of this system, i.e., on the direct relationships between the variables. The creation of a structure is, of course, the most essential step in model building. During this stage various specifications of the equations may be tried out and the properties of the residual terms of the structural equations considered, with the object of discovering the appropriateness of the various specifications.

If the model is determined, in the sense that the number of endogenous variables equals that of equations, it can be solved for the endogenous variables, to express each of them as a function of the lagged endogenous and the exogenous variables. This may also enable one to get to grips with the indirect relationships existing between the variables, i.e., to utilize all the information inherent in the model.[3] The reduced form of the model is particularly well suited for predictive purposes: it is sufficient to know the values of the predetermined variables in order to compute the forecast values of the endogenous variables from the model. A picture of the efficiency of the model as a whole can be obtained by consideration of the reduced form.

When the final equation method is employed as a technique of prediction, even less information is required. This method can, however, only be applied if the model is dynamic, i.e., includes at least one lagged endogenous variable. In order to solve the model, each of the endogenous variables is expressed as a function of its own lagged values and of all the exogenous variables. Thus, a system of difference equations is obtained. When the solution of such a system is used for purposes of prediction, the requisite amount of information is the smallest possible: only the values of the exogenous variables for the prediction period and the initial values of the endogenous variables must be available. The problem of prediction will not, however, be discussed here at greater length. Instead, the dynamic structure of the estimated empirical model will be analyzed. The final equation method also results in a set of equations which contains all the information inherent in the model, i.e., all the direct and indirect relationships involved in the original system of structural equations.

3. If a model is exactly identified, it can be estimated in the reduced form, and the structural parameters can then be computed from the relationships existing between these parameters and the parameters of the reduced form.

In the analysis of the dynamic structure of the model, attention will be paid, among other things, to the influence over time of changes in the exogenous variables on the endogenous variables. By employing the final equation method it is possible to discover whether the effects of an exogenous shock are of short or long duration; i.e., whether the effect is damped rapidly or slowly and whether the interdependences involved in the system tend to reinforce the effects of the shock. In other words, an effort is made to discover whether the endogenous variables move towards a state of equilibrium or away from it. The method also permits investigating whether this movement proceeds monotonically or whether it displays cyclical fluctuations.

Moreover, the final equation technique makes it possible to obtain qualitative information on how far the behavioural assumptions incorporated in the structural equations are reasonable. If the equilibrium values characterizing the dynamic time path are not logical, even though the assumptions concerning the exogenous variables are otherwise reasonable, this may be taken as an indication that there is something wrong with the basic model, i.e., that a specification error has been committed. A well-known property of the final equation method is this: provided that the system is truly simultaneous, the coefficients of all the lagged endogenous variables will be equal.[4] This implies that it is enough to analyze the dynamic properties of a single variable, since the conclusions reached can be extended to all the other endogenous variables. On the other hand, when the analysis is confined to a single endogenous variable, the quantitative and qualitative information contained in the values of the coefficients of the exogenous variables of the final equations concerning the net effects of these variables remains unused.

Final equations will be derived here for a number of »interesting» variables of the model. These include the price level p, the earnings level w^e, the real wage variable w^e/p which can be constructed by means of these two, and the employment rate variable N^d/N^s which can be constructed on the basis of the demand for and supply of labour functions. The behaviour of the unemployment percentage, defined as $100\ (1 - N^d/N^s)$ can also be investigated with the aid of the last-mentioned variable.

Prior to the numerical analysis, some of the analytical tools to be employed will be considered. These include the solution formulae. A basic model can

4. In the Klein—Goldberger model, for example, two mutually independent sub-models are formed by the monetary and the real sectors respectively; hence, only the solution of the final equation for the real sector includes a cyclical component. See A. S. GOLDBERGER Impact Multipliers and Dynamic Properties of the Klein—Goldberger Model, Amsterdam 1959, especially p. 134. Goldberger terms such a system »decomposable».

easily be transformed into final equation form by means of matrix methods.[5] Since the model dealt with in this study is of the first order in the endogenous variables, the analysis of its dynamic properties will not be difficult. Assume that we have a linear difference equation of the first order with constant parameters:

(6.14) $y_t - a\, y_{t-1} = f(t)$,

where y_t is an endogenous variable and y_{t-1} the same variable lagged one period, a being a parameter which is a function of the parameters of the original structural form and $f(t)$ being a forcing function which contains, in the case of an empirical model, all the information inherent in the exogenous variables of the model. The homogeneous part of (6.14) is

(6.15) $y_t - a\, y_{t-1} = 0.$

Its solution is simply

(6.16) $y_t = y_o\, a^t$,

where y_o is the initial value.

The shape of the time path of the solution chiefly depends on the parameter a. If a is numerically greater than unity, the time path is explosive; and if it is numerically less than unity, the solution is damped. Further, if a is a positive number, the movement proceeds monotonically; and if a is negative, the movement is oscillatory. The particular solution of the difference equation (6.14) depends on the function $f(t)$. If $f(t)$ is constant, the solution is easy to find:

(6.17) $\bar{y} = k/(1 - a)$.

The particular solution $\bar{y}$ may also be termed the stationary equilibrium value of the system. Variations take place about the value of $\bar{y}$ as obtained from (6.17). The general solution can then be written as:[6]

(6.18) $y_t = y_o\, a^t + \bar{y}$.

The dynamic properties of the total model will be discussed below on the basis of the transformed Excess Demand Model I. This particular model was selected for two different reasons. First, it is easy to analyze: complications

5. See, e.g., A. S. Goldberger op. cit., pp. 105—114, or W. Baumol Economic Dynamics, 2nd edition, New York 1959, Chapter XVI.

6. For details of the technique outlined above, see, e.g., R. G. D. Allen Mathematical Economics, New York 1960.

due to the constant parameter and the seasonal variables, characteristic of the untransformed models are absent here. Secondly, the conclusions arrived at by transforming the variables of a model to first differences are also valid for the untransformed model.[7] Moreover, although both of the transformed excess demand models, unlike the transformed capacity models, met the requirements concerning inner logic, this was the »more dynamical» of the two.

In the following analysis the stochastic properties of the model will be disregarded, and the model will be considered as if it were exact. Nevertheless the conclusions to be put forward should be interpreted in a probability sense. The structure of the model forming the point of departure can be written

$$(6.19) \quad \Delta\, ln\, p = .782\, \Delta\, ln\, w^e - .337\, \Delta\, ln\, T + .080\, \Delta\, ln\, p^{imp}_{-2} - .721\, \Delta\, ln\, h$$

$$(6.20) \quad \Delta\, ln\, w^r = .846\, \Delta\, ln\, p_{-1} + .276\, \Delta\, ln\, T + .659\, \Delta\, ln\, p^*_{-1} + .369\, \Delta\, ln\, h$$

$$(6.21) \quad \Delta\, ln\, (w^e/w^r) = .020 + .561\, \Delta\, ln\, h + .902\, \Delta\, ln\, (N^d/N^s)$$

$$(6.22) \quad \Delta\, ln\, h = -\, .830\, \Delta\, ln\, (N^d/N^s) + .213\, \Delta\, ln\, (Y^d/Y^s)_{-2}$$

$$(6.23) \quad \Delta\, ln\, N^d = .529\, \Delta\, ln\, Y - .083\, \Delta\, ln\, (w^e/p) - .371\, \Delta\, ln\, T$$

$$(6.24) \quad \Delta\, ln\, N^s = .351\, \Delta\, ln\, V + .110\, \Delta\, ln\, (w^e/p) + .081\, \Delta\, ln\, (Y^d/Y^s)_{-2}$$

When the system (6.19)—(6.24) is solved for the endogenous variables, so as to express each of these in terms of the exogenous variables and its own lagged values, the system of final equations obtained for p, w^e and N^d/N^s is

$$(6.25) \quad \begin{aligned} \Delta\, ln\, p = {} & .015 + .634\, \Delta\, ln\, p_{-1} + .416\, \Delta\, ln\, Y - .473\, \Delta\, ln\, T \\ & + .494\, \Delta\, ln\, p^*_{-1} - .092\, \Delta\, ln\, (Y^d/Y^s)_{-2} - .276\, \Delta\, ln\, V \\ & + .092\, \Delta\, ln\, p^{imp}_{-2} \end{aligned}$$

7. Although the analysis is carried out in terms of the first differences of the variables, the conclusions can easily be generalized to apply to the dynamic time paths of the original variables; for if the initial value of $log\, y$ is $log\, y_o$, we have

$$log\, y_T = log\, y_o + \Delta\, log\, y_1 + \ldots + \Delta\, log\, y_T.$$

Goldberger has shown that the dynamic properties of the model will be the same, irrespective of whether it is formulated in terms of the original variables or their first differences. Dynamic properties such as stability or periodicity will be possessed by the original model if they are possessed by the transformed model. See GOLDBERGER op. cit., pp. 113—114.

$$(6.26)\quad \Delta\, ln\, w^e = .020 + .634\, \Delta\, ln\, w^e_{-1} + .077\, \Delta\, ln\, Y + .301\, \Delta\, ln\, Y_{-1} + .213\, \Delta\, ln\, T - .532\, \Delta\, ln\, T_{-1} + .655\, \Delta\, ln\, p^*_{-1} + .180\, \Delta\, ln\, (Y^d/Y^s)_{-2} - .192\, \Delta\, ln\, (Y^d/Y^s)_{-3} - .052\, \Delta\, ln V - .199\, \Delta\, ln\, V_{-1} + .002\, \Delta\, ln\, p^{imp}_{-2} + .076\, \Delta\, ln\, p^{imp}_{-3}$$

$$(6.27)\quad \Delta\, ln\, (N^d/N^s) = -.001 + .634\, \Delta\, ln\, (N^d/N^s)_{-1} + .594\, \Delta\, ln\, Y - .393\, \Delta\, ln\, Y_{-1} - .503\, \Delta\, ln\, T + .338\, \Delta\, ln\, T_{-1} - .031\, \Delta\, ln\, p^*_{-1} - .133\, \Delta\, ln\, (Y^d/Y^s)_{-2} + .088\, \Delta\, ln\, (Y^d/Y^s)_{-3} - .394\, \Delta\, ln\, V + .261\, \Delta\, ln\, V_{-1} + .017\, \Delta\, ln\, p^{imp}_{-2} - .015\, \Delta\, ln\, p^{imp}_{-3}$$

By (6.25) and (6.26) a final equation can be derived for changes in w^e/p, to obtain

$$(6.28)\quad \Delta\, ln\, (w^e/p) = .005 + .634\, \Delta\, ln\, (w^e/p)_{-1} + .339\, \Delta\, ln\, Y + .301\, \Delta\, ln\, Y_{-1} + .686\, \Delta\, ln\, T - .532\, \Delta\, ln\, T_{-1} + .161\, \Delta\, ln\, p^*_{-1} + .272\, \Delta\, ln\, (Y^d/Y^s)_{-2} - .192\, \Delta\, ln\, (Y^d/Y^s)_{-3} + .224\, \Delta\, ln\, V - .199\, \Delta\, ln\, V_{-1} - .090\, \Delta\, ln\, p^{imp}_{-2} + .076\, \Delta\, ln\, p^{imp}_{-3}$$

Let us first consider the homogeneous part of the price equation (6.25). This is

$$(6.29)\quad \Delta\, ln\, p - .634\, \Delta\, ln\, p_{-1} = 0.$$

Here the numerical value of the parameter corresponding to a in (6.15) is .634. Thus, the parameter is positive and less than unity. Hence, the time path of the inflation is stable: following a departure from equilibrium due to an exogenous shock the system returns to equilibrium without cyclical fluctuations. The return takes place rapidly; for if (6.29) is considered as a distributed lag model, the length of the mean lag is about 5 months.[8] The above conclusions also apply to the homogeneous equations corresponding to equations (6.26)—(6.28), as the numerical value of the reaction parameter is the same in these equations as in (6.29).

To find the particular solution, certain assumptions concerning the behaviour of the exogenous variables of the model must be introduced. Let these assumptions be as follows:

8. The length of the mean lag can be computed from the formula: mean lag $= a/(1 - a) = .634/.366 \approx 1.7$ quarters ≈ 5 months.

$$\Delta\, ln\, Y = .0468$$
$$\Delta\, ln\, T = .0369$$
$$\Delta\, ln\, p^* = .0000$$
$$\Delta\, ln\, (Y^d/Y^s) = .0000$$
$$\Delta\, ln\, V = .0136$$
$$\Delta\, ln\, p^{imp}_{-2} = .0437$$

A characteristic feature of $\Delta\, ln\, p^*$ and $\Delta\, ln\, (Y^d/Y^s)$ is that both fluctuate about the zero level, and thus it is natural to take them as equal to zero when an equilibrium solution is being sought. Each of the other variables, by contrast, was assumed to follow the trend it had shown during the sample period chosen for this study. When these values were assigned to the exogenous variables of (6.25)—(6.28), these assumed the form

$$\Delta\, ln\, p - .634\, \Delta\, ln\, p_{-1} = + .017 \tag{6.30}$$

$$\Delta\, ln\, w^e - .634\, \Delta\, ln\, w^e_{-1} = + .026 \tag{6.31}$$

$$\Delta\, ln\, (N^d/N^s) - .634\, \Delta\, ln\, (N^d/N^s)_{-1} = \pm .000 \tag{6.32}$$

$$\Delta\, ln\, (w^e/p) - .634\, \Delta\, ln\, (w^e/p) = + .009 \tag{6.33}$$

Finally, solving these equations,

$$\Delta\, ln\, p = .634^t\ \Delta\, ln\, p_o + .046 \tag{6.34}$$

$$\Delta\, ln\, w^e = .634^t\ \Delta\, ln\, w^e_o + .071 \tag{6.35}$$

$$\Delta\, ln\, (N^d/N^s) = .634^t\ \Delta\, ln\, (N^d/N^s)_o \tag{6.36}$$

$$\Delta\, ln\, (w^e/p) = .634^t\, \Delta\, ln\, (w^e/p)_o + .025 \tag{6.37}$$

6.3. SOME ECONOMIC AND ECONOMIC-POLICY IMPLICATIONS OF THE DYNAMIC ANALYSIS

Now that the technical part of the dynamic analysis of the model has been completed we can proceed to its economic implications. This phase of the analysis may also be regarded as an additional test of the realism of the model. In this context the results will be compared with those obtained in other studies.

Another interesting aspect to be considered here is that of the economic policy recommendations warranted by the model. Judging by the present model, how efficient is devaluation as a means of improving a country's international competitiveness? Is its influence on competitiveness only temporary? Over how long a period of time are its inflationary effects spread? We might consider, in addition, the implications of the model concerning economic policy goals such as price stability and full employment. Can these goals be achieved simultaneously and, if so, under what conditions? Or are they mutually exclusive? Here, too, the points of view put forward in other comparable studies will be considered.

Each of the parameter values in the final equations indicates the net effect of an exogenous variable on an endogenous variable. The results obtained here concerning these net effects differ to some extent from those arrived at in other studies. Inspection of price equation (6.25) reveals that increases in productivity and population growth, for example, are factors that tend to lower the price level, whereas rising import prices and increasing total output tend to raise it. The results thus support those assumptions according to which economic growth can only be achieved at the expense of price stability. During the sample period the joint effect of all these exogenous variables on the price level was (according to equation (6.30)) an average increase of 1.7 per cent a year.

The net effect of the productivity variable in the price equation has been an extensively discussed topic. In the model developed by KLEIN's group the net effect was positive.[9] BALL, one of Klein's associates, interpreted this finding as indicating that the changes in relative prices accompanying economic growth may result in a positive net effect.[10] Other studies concerning the United Kingdom have suggested, however, that the net effect of increases in productivity on the price level is negative.[11] Since increasing productivity is a factor directly reducing production costs, a negative rather than a positive sign would be expected to appear in the final equation on *a priori* grounds.

On the other hand, the result arrived at in this study concerning the net effect of variations in total output on changes in the price level is similar to that obtained by Klein and his associates, who found that the price level increased at a rate of three index points if production was growing at the rate of eight index points.[12] By (6.25), the rates of increase in the price level and output were in a ratio of 2 to 5.

9. See L. R. KLEIN, R. J. BALL, A. HAZLEWOOD & P. VANDOME op. cit., p. 115.
10. See the discussion in J. D. SARGAN op. cit., p. 59—60.
11. See L. A. DICKS-MIREAUX op. cit., p. 273, and J. D. SARGAN op. cit., p. 47.
12. See L. R. KLEIN, R. J. BALL, A. HAZLEWOOD & P. VANDOME op. cit., p. 271.

The level of earnings increased under the impact of the exogenous variables at an annual average rate of 2.6 per cent over the sample period, and the rise in real earnings averaged 1 per cent per annum (according to equations (6.31) and (6.33)). The employment rate did not change as a result of the impact of the exogenous variables (equation (6.32)).

From (6.34) — (6.37) the following stationary equilibrium values are obtained for the endogenous variables:

$$\Delta\, ln\, \bar{p} = +\, 4.6\ \%$$
$$\Delta\, ln\, \bar{w}^e = +\, 7.1\ \%$$
$$\Delta\, ln\, (\bar{N}^d/\bar{N}^s) = +\, 0.0\ \%$$
$$\Delta\, ln\, (\bar{w}^e/\bar{p}) = +\, 2.5\ \%$$

The values are exactly equal to the average percentage rates of change of these variables during the sample period.[13]

One further, extensively discussed question, namely, the influence of devaluation on the price level, can also be considered in terms of the present model. Some authors hold that devaluation improves a country's competitiveness only temporarily, because the competitive advantage it creates will quickly be lost totally, as a result of the inflationary process initiated by it. Others feel that a permanent improvement in a country's competitive position can be achieved through devaluation. Attempts have also been made to approach this question empirically. SARGAN's study of the United Kingdom suggested that 90 per cent of the improvement in competitiveness resulting from devaluation is lost in eleven years, as a result of increased costs of production. He felt that this result contradicted the views according to which the effects of devaluation are only temporary.[14]

This issue is considered below in the light of the present model, on the assumption that a devaluation of 30 per cent has been undertaken. It will be assumed, further, that the devaluation results in an immediate rise of the same size in import prices. The analysis will be based on equation (6.25).

13. According to the calculations of Goldberger, the equilibrium values of the price and wage levels implied by the Klein—Goldberger model are much less reasonable: —61 and —76 index points a year. Goldberger points out, however, that economically meaningful time paths will result, despite the unreasonable equilibrium values, if the initial values are specified appropriately. See A. S. GOLDBERGER op. cit., pp. 116—119.

14. See J. D. SARGAN op. cit., 48.

If the other exogenous variables are assumed to remain unchanged, the equation can be rewritten[15]

$$(6.38) \quad \Delta\, ln\, p - .634\, \Delta\, ln\, p_{-1} = .092\, \Delta\, ln\, p^{imp}_{-2}$$

The rise in import prices occasioned by devaluation only begins to influence the price level after two quarters.[16] The time paths of the price level and import prices during the first twelve quarters following devaluation are, in terms of percentage changes, as follows.

	$(\Delta p/p) \times 100$	$(\Delta p^{imp}/p^{imp}) \times 100$
I quarter	0	30
II ,,	0	30
III ,,	2.76	30
IV ,,	4.51	30
V ,,	5.62	0
VI ,,	6.32	0
VII ,,	4.01	0
VIII ,,	2.54	0
IX ,,	1.61	0
X ,,	1.02	0
XI ,,	0.65	0
XII ,,	0.41	0

By the end of the twelfth quarter, when prices have risen by 7.36 per cent, almost 98 per cent of the total rise due to the inflationary process has been realized. Thus, the increase in prices caused by devaluation will amount to approximately a quarter of the devaluation percentage. Hence, from this point of view the improvement in competitiveness due to devaluation can be regarded as permanent. Moreover, the movement in the price level due to the impact of devaluation is almost totally damped within three years. This result can be taken to be in sharp contrast to Sargan's findings, according to which the influence of devaluation was spread over a long period of time and the competitive advantage was almost completely lost by the

15. A reservation, which arises from the fact that the commodity market is considered as an exogenous element in the present model, should be made at this point: the influence of devaluation on demand and supply conditions in the commodity market is disregarded in the analysis.

16. This time lag of two quarters should be considered as an average lag typical of the sample period. In practice, however, the influence of such a powerful shock as devaluation begins to be felt immediately.

end of this period. In the present case the inflationary effects of devaluation died away rapidly, and only a quarter of the advantage due to it was lost.

Next we proceed to consider full employment and price stability as simultaneous policy goals in the light of the present model. Initially, however, the conclusions drawn from certain other studies, will briefly be discussed. Sargan's study led to the view that a stable wage level cannot be attained at any rate of unemployment and that inflation can only be checked through increasing productivity. The attainment of wage stability would presuppose a rate of increase in productivity of 10 per cent a year and a rate of increase of 6.7 per cent would be necessary for price level stability. The existence of unemployment would, however, be necessary for a stable wage level.[17]

On the other hand, PHILLIPS's well-known study led to the conclusion that, when productivity is increasing at an annual rate of 2 per cent, a stable wage level can be achieved at an unemployment rate of 5.5 per cent and a stable price level at a rate of 2.5 per cent.[18] PERRY's study also suggested that price stability could not be achieved, except in the presence of unemployment. If wages were permitted to rise *pari passu* with productivity, and if productivity increased at an annual rate of 2.5 per cent, the unemployment rate would be 8.1 per cent. The rate of unemployment corresponding to an annual rate of increase in productivity of 4 per cent would be 8.1 per cent. Profits were assumed to remain at a level corresponding to the average for the sample period 1947—1960.[19] SAMUELSON's and SOLOW's study suggested that an unemployment rate of rather more than 8 per cent would be necessary for the stabilization of the wage level; and a rate of 5.5 per cent would be a necessary condition for price stability. If productivity were increasing at an annual rate of 2.5 per cent, an unemployment rate of 5 to 6 per cent would be necessary for the stability of wage rates.[20] According to experiments made by T. HELELÄ with Finnish data, price stability could be achieved at a rate of unemployment of 4 per cent.[21]

In all the above studies unemployment was dealt with as an exogenous variable, despite the fact that it is intrinsically endogenous. Hence, the simultaneous occurrence of price and wage increases and unemployment — which is

17. J. D. SARGAN op. cit., p. 48.

18. A. W. PHILLIPS »The Relation between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861—1957», *Economica*, Nov. 1958, pp. 298—299.

19. G. L. PERRY Unemployment, Money Wage Rates, and Inflation, The M.I.T. Press 1966, p. 59.

20. P. A. SAMUELSON & R. M. SOLOW »Analytical Aspects of Anti-Inflation Policy» in *The Collected Scientific Papers of Paul A. Samuelson*, II, The M.I.T. Press 1966.

21. T. HELELÄ »Hintojen muutoksista ja niiden ennakoinnista», *KAK* No. 1, 1961.

a common feature of the periods of observation in all these studies — affects the results and implies restrictions on the conclusions. Since prices, wages and unemployment are endogenous in the last analysis, they are ultimately dependent on a number of exogenous variables; and these exogenous variables primarily determine the nature of price and wage movements relative to unemployment. We may ask, in other words, whether a combination of values of the exogenous variables can be found, such that full employment and price stability are simultaneously achieved.

Equations (6.25) — (6.27) express the price and wage levels and the rate of employment as functions of the exogenous variables relevant to this study. Let us consider the behaviour of these equations in a stationary state, assuming that all the exogenous variables except output and productivity follow the trends that they were found to follow during the sample period. Changes in price and wage levels and in the employment rate can then be expressed as functions of changes in output and productivity as follows:

(6.39) $\Delta ln\, p = .041 + 1.137\, \Delta ln\, Y - 1.292\, \Delta ln\, T$

(6.40) $\Delta ln\, w^e = .055 + 1.030\, \Delta ln\, Y - .872\, \Delta ln\, T$

(6.41) $\Delta ln(N^d/N^s) = -.005 + .549\, \Delta ln\, Y - .451\, \Delta ln\, T$

Equating the left sides of these equations with zero, the graphs shown in Figure 5 are obtained.

In Figure 5 the straight line A represents those combinations of output and productivity at which the price level remains stable. The combinations to the right correspond to declining prices and those to the left to rising prices. In the same way, the level of earnings is falling at output-productivity combinations to the right of the line B and rising at combinations to the left of B. The region between A and B contains the points at which the level of earnings is rising and the price level declining. The employment rate decreases below the line C and increases above it. If there is underemployment in the initial situation and full employment is chosen as the policy goal, it is necessary to achieve a combination of the rates of increase in output and productivity that will lead to full employment. There is a multitude of such combinations, and all are located in a straight line running above C and parallel to it, the distance of this line from C depending on the rate of unemployment in the initial situation. Upon achieving full employment, price and wage levels can be stabilized by selecting that combination of the rates of increase in output and productivity which corresponds to the point of intersection of A and C. Here, the percentage rates of change in the other variables that ensure both price stability and full employment are, in the present case, the following:

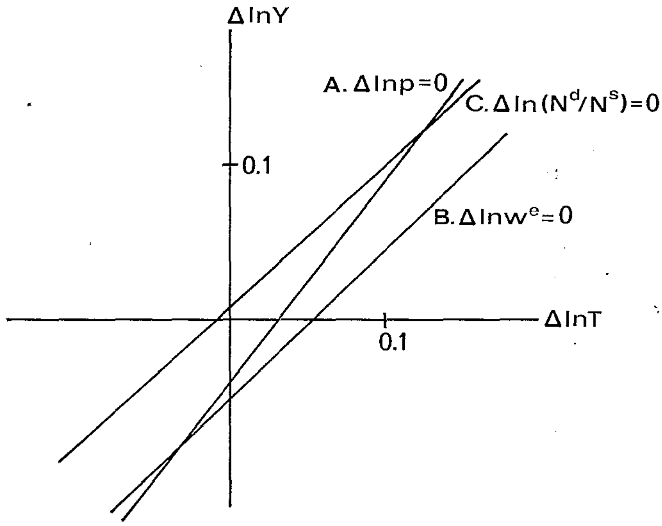

Figure 5.

	%
Change in output,	+ 12.6
Change in productivity,	+ 14.3
Change in earnings level,	+ 2.5

Thus, a combination of the values of the exogenous variables does exist at which price stability and full employment can be achieved simultaneously These values are, however, economically unrealistic.

A similar experiment was carried out with Capacity Model I, but the result did not differ appreciably from the one discussed above. A number of alternative explanations can be suggested for this state of affairs. First, the effect of the exogenous variables is bound to remain small when their means, as computed for the entire sample period, are employed. Moreover, since the original equations do not involve any constant terms, the derived equation system (6.39) — (6.41) becomes nearly homogeneous.[22] Secondly, the interdependence between variables $\check{Y}$ and T may have distorted the parameter estimates obtained for these variables in the demand for labour equation; in consequence, the derived parameter estimates, especially those in equation (6.41), may also be biased. Even slight biases in the estimates for the parameters in any one of the original equations will affect, in simultaneous analysis, most of the parameter values in the derived equations.

22. A homogeneous equation system is of the form $Ay = O$, where y is the vector of the endogenous variables and A the coefficient matrix. No (non-trivial) solution can be found for such a system in terms of the absolute values of the y's.

7. CONCLUDING REMARKS

Two types of inflation theories on which interest has focused in recent decades were briefly considered in the Introduction to this study. Following this, a historical survey was given of the origins and development of the approaches underlying these theories, which have provided a basis for the intensive theoretical and empirical research in which numerous economists have been engaged during the post-war era. Particular attention was called to the fact that, judging by the empirical results obtained hitherto, price stability and full employment appear to be mutually incompatible goals of economic policy. This provided one of the staring points for the present study. There seemed to be reason to experiment with a different type of model from the excess demand and cost push models the use of which, as structural components of models designed to explain the inflationary mechanism, has become more or less traditional.

The model constructed in the present study was termed a disequilibrium model, since it permits demand and supply to be in disequilibrium at the equilibrium values of the endogenous variables. In point of fact, since the basic model is static, indicators of the disequilibrium of demand and supply corresponding to any one equilibrium solution can be derived from it. Adjustment was totally excluded from the model, and only shifts from one disequilibrium to another were considered. The disequilibria are a consequence of changes in the exogenous variables of the model.

By relating each state of disequilibrium to the point of intersection between the demand and supply curves corresponding to it, an inflationary mechanism of the cost-push type was incorporated into the model, despite the fact that the price and wage levels entered into the original model exclusively as functions of excess demand. In this model the role of excess demand is, however, different from that it plays in traditional models: instead of being the factor initiating adjustment, it is a static element in the model.

Attention was devoted to both the theoretical and empirical aspects of the problem. An effort was made to formulate the hypotheses based on theoretical considerations so as to render them almost directly amenable to empirical testing. In other words, the intention was to make the gap between theory and empirical research as narrow as possible. As a result of the absence of separate detailed data on demand and supply in the commodity market, however, the chief emphasis in the empirical study rested on labour market variables.

The basic model is a short-run model. Nevertheless, certain long-run effects had to be allowed for in the empirical analysis. Each observation on any one variable included in the model represents a specific short-run situation; yet, when several successive observations are considered simultaneously by means of time series analysis, these long-run influences tend to affect the interrelationships between the observations, with the result that the parameters of the model are bound to change over time. This can be avoided, at least in part, by introducing factors representing long-term effects as explicit variables into the model. The inclusion of variables representing changes in productivity and population growth, for example, can be justified in this way.

The empirical analysis consisted of three parts. Initially, the model was considered equation by equation, with the object of discovering structures which would satisfactorily meet certain empirical and logical criteria. Following this, a simultaneous analysis of the model was undertaken.

The behaviour of the model as a whole was investigated by employing a particular variant of it selected in connection with the simultaneous analysis. The dynamic analysis of the model revealed that the parameter values obtained by simultaneous estimation implied that the time path of the inflationary process would be stable. The next task was to consider the significance of certain exogenous variables as elements of the empirical model. It was discovered, for example, that the effects of devaluation died away comparatively rapidly and that the improvement in competitiveness due to devaluation seemed to be of a permanent nature in the light of the present data. By expressing the endogenous variables of the model in terms of the exogenous variables alone, it was possible to find a combination of the values of the exogenous variables at which price stability and full employment were simultaneously attainable. The values were not, however, economically reasonable.

LIST OF SYMBOLS

p	= price level
w	= wage level (in general sense)
w^e	= earnings level
w^r	= level of negotiated wage rates
w^e/w^r	= wage drift
p^c	= cost of living index
p^*	= p^c/p = ratio between cost of living index and general price level
w/p	= real wage level (in general sense)
w^e/p	= level of real earnings
p^i	= import prices
p^{ir}	= prices of imported raw materials
p^{ii}	= prices of imported investment goods
p^{imp}	= $\lambda p^{ir} + (1-\lambda)p^{ii}$
N	= realized employment
N^d	= demand for labour
N^s	= supply of labour
N^d/N^s	= excess demand for labour
N^e	= labour input
V	= population of working age
Y	= realized output
Y^d	= demand for commodities
Y^s	= supply of commodities
Y^d/Y^s	= excess demand for commodities
T	= productivity of labour
h	= average hours worked
t	= time

APPENDIX I

Estimation Results, Tables 1—14

The results given in Tables 1—7 were obtained by the ordinary least squares method.

The OLS-estimates in Tables 8—14 were obtained by the ordinary least squares method.

The TSLS-estimates in Tables 8—14 were obtained by the two-stage least squares method.

Table 1. Dependent variable ln p

Eq.	Constant	$ln\ w^e$	$ln\ T$	$ln\ p^{ir}$	$ln\ p^{ir}_{-2}$	$ln\ p^{ii}$	$ln\ p^{ii}_{-2}$	$ln(Y^d/Y^s)$	$ln(Y^d/Y^s)_{-2}$	S_1	S_2	S_3	R	$D—W$
(5.3)	.826	.464	.281	.070				—.529		—.004	—.007	.019	.997	1.814
	(3.165)	(7.980)	(2.464)	(1.813)				(3.990)		(.834)	(1.296)	(3.313)		
(5.4)	1.482	.653	—.093	.116					—.080	.000	—.010	.023	.995	1.453
	(6.018)	(16.844)	(1.264)	(2.629)					(.957)	(.012)	(1.607)	(3.295)		
(5.5)	1.033	.505	.189		.078			—.435		—.003	—.009)	.018	.997	1.804
	(4.234)	(8.168)	(1.510)		(2.329)			(3.041)		(.563)	(1.827)	(3.347)		
(5.6)	1.588	.668	—.144		.131				—.011	.001	—.014	.021	.996	1.527
	(8.612)	(18.873)	(2.097)		(3.826)				(.141)	(.078)	(2.385)	(3.210)		
(5.7)	1.139	.498	.178	.032		.039		—.434		—.002	—.007	.022	.997	1.904
	(2.810)	(7.416)	(1.163)	(.606)		(1.008)		(2.678)		(.257)	(1.251)	(3.372)		
(5.8)	1.962	.653	—.180	.003		.096			—.052	.006	—.008	.030	·996	1.777
	(6.871)	(18.460)	(2.428)	(.060)		(2.724)			(.683)	(.847)	(1.394)	(4.344)		
(5.9)	1.947	.668	—.205		.048		.066		.001	.003	—.015)	.023	.996	1.764
	(7.717)	(19.707)	(2.823)		(.913)		(1.990)		(.542)	(.542)	(2.714)	(3.672)		

Table 2. Dependent variable ln p

Eq.	Constant	$ln\ w^e$	$ln\ T_{-2}$	$ln\ p^{imp}_{-2}$	$ln\ (Y^d/Y^s)$	$ln\ (Y^d/Y^s)_{-2}$	S_1	S_2	S_3	R	$D—W$
(5.11)	1.278	.528	.112	.080	—.329		—.002	—.012	.018	.997	1.804
	(8.196)	(14.669)	(1.544)	(3.232)	(4.049)		(.439)	(2.323)	(3.368)		
(5.12)	1.500	.588	—.013	.097		—.070	—.002	—.012	.018	.996	1.720
	(6.200)	(10.065)	(.094)	(2.307)		(.473)	(.331)	(1.972)	(2.620)		

Table 3. Dependent variable $ln\ w^e$

Eq.	Constant	$ln\ p_{-1}$	$ln\ p_{-2}$	$ln\ T$	$ln\ p^*_{-1}$	$ln\ p^*_{-2}$	$ln\ (N^d/N^s)$	S_1	S_2	S_3	R	$D—W$
(5.20)	—2.561	1.690		—.134	1.147		3.447	.050	.021	.013	.994	1.021
	(11.445)	(15.006)		(.888)	(5.285)		(3.469)	(3.215)	(2.044)	(1.142)		
(5.21)	—2.573		1.744	—.176		.881	2.817	.016	.014	—.006	.996	1.436
	(8.416)		(10.815)	(.826)		(3.298)	(2.263)	(.860)	(1.138)	(.499)		

Table 4. Dependent variable $ln\ w^e$

Eq.	Constant	$ln\ p$	$ln\ T$	$ln\ p^*$	$ln(N^d/N^s)_{-1}$	$ln\ (N^d/N^s)_{-2}$	S_1	S_2	S_3	R	$D—W$
(5.22)	—3.061	1.488	.153	.906	1.736		.007	.037	—.005	.998	1.097
		(27.896)	(2.380)	(7.005)	(5.471)		(1.004)	(5.697)	(.699)		
(5.23)	—3.061	1.427	.238	.837		1.335	—.003	.019	—.000	.998	1.332
		(25.623)	(3.608)	(5.921)		(4.294)	(.401)	(3.001)	(.051)		

Table 5. Dependent variable $ln\ w^e$

Eq.	Constant	$ln\ p$	$ln\ T_{-1}$	$ln\ T_{-2}$	$ln\ p^*$	$ln\ (N^d/N^s)$	S_1	S_2	S_3	R	$D—W$
(5.24)	—2.588	1.620	—.058		1.027	3.085	.027	.012	—.017	.998	1.096
		(21.674)	(.585)		(7.097)	(4.824)	(3.742)	(1.778)	(1.599)		
(5.25)	—2.537	1.651		—.101	1.031	3.301	.035	.011	—.011	.998	1.046
		(21.171)		(.971)	(7.202)	(4.975)	(3.412)	(1.705)	(1.503)		

Table 6. Dependent variable $ln\ w^r$

Eq.	Constant	$ln\ p_{-1}$	$ln\ T$	$ln\ p^*_{-1}$	$ln\ (N^d/N^s)$	$ln\ (N^d/N^s)_{-1}$	S_1	S_2	S_3	R	$D—W$
(5.38)	—.590	1.064	.065	.974	.977		.028	.017	.002	.997	2.054
		(16.119)	(.739)	(7.641)	(1.679)		(3.068)	(2.812)	(.329)		
(5.39)	—.670	1.047	.099	.925		.764	.022	.028	.007	.997	1.960
		(21.488)	(1.676)	(8.671)		(2.832)	(3.410)	(4.678)	(1.072)		

Table 7. Dependent variable $\Delta\ ln\ w^r$

Eq.	$\Delta\ ln\ p_{-1}$	$\Delta\ ln\ T$	$\Delta\ ln\ p^*_{-1}$	$\Delta\ ln\ (N^d/N^s)$	$\Delta\ ln\ (N^d/N^s)_{-1}$	R	$D—W$
(5.40)	.929	.176	.723	.529		.968	1.854
	(11.780)	(1.944)	(5.753)	(1.027)			
(5.41)	.977	.144	.738		.784	.974	1.832
	(15.410)	(2.192)	(7.115)		(2.953)		

Table 8. Dependent variable: Price level ln p and change in price level Δ ln p

Independent variables	Estimates of regression coefficients											
	Untransformed equations *(ln)*						Transformed equations *(Δ ln)*					
	Excess Demand Model I TSLS	Excess Demand Model II TSLS	Excess Demand Model I & II OLS	Capacity Model I TSLS	Capacity Model II TSLS	Capacity Model I & II OSL	Excess Demand Model I TSLS	Excess Demand Model II TSLS	Excess Demand Model I & II OSL	Capacity Model I TSLS	Capacity Model II TSLS	Capacity Model I & II OSL
Constant	2.754	2.387	1.851	1.921	1.871	1.826	—	—	—	—	—	—
			(2.036)			(11.941)						
w^e	.707	.688	.666	.689	.676	.664	.782	.745	.710	.685	.658	.653
	(14.939)	(12.590)	(17.858)	(18.130)	(15.238)	(20.127)	(8.759)	(7.749)	(10.867)	(9.422)	(8.280)	(11.701)
T	—.251	—.223	—.190	—.230	—.206	—.183	—.337	—.289	—.247	—.192	—.162	—.155
	(3.119)	(2.387)	(2.822)	(2.986)	(2.288)	(2.721)	(2.630)	(2.092)	(2.547)	(1.846)	(1.420)	(1.873)
p^{imp}_{-2}	.125	.126	.126	.123	.123	.122	.080	.086	.093	.066	.072	.073
	(4.317)	(3.740)	(4.853)	(3.911)	(3.339)	(4.271)	(2.393)	(2.396)	(3.332)	(1.815)	(1.809)	(2.431)
h	—.178	—.109	—.005				—.721	—.568	—.505			
	(.611)	(.327)	(.024)				(1.787)	(1.299)	(1.892)			
$(Y^d/Y^s)_{-2}$				—.013	—.018	—.022				—.174	—.173	—.173
				(.160)	(.186)	(.301)				(1.904)	(1.727)	(2.236)
S_1	.003	.003	.003	.005	.004	.003						
	(.382)	(.306)	(.421)	(.679)	(.481)	(.500)						
S_2	—.020	—.018	—.015	—.016	—.015	—.015						
	(2.216)	(1.745)	(2.206)	(2.558)	(2.147)	(2.706)						
S_3	.013	.017	.022	.024	.023	.022						
	(.732)	(.790)	(1.723)	(3.595)	(2.977)	(3.731)						
R	.995	.993	.996	.995	.993	.996	.938	.928	.954	.937	.925	.956
$D—W$	1.595	1.837	1.732	1.541	1.822	1.761	1.324	1.419	1.405	1.311	1.367	1.553

Table 9. Dependent variable: Earnings level ln w^e and change in earnings level Δ ln w^e

Independent variables	Estimates of regression coefficients							
	Untransformed equations (*ln*)				Transformed equations (Δ *ln*)			
	Excess Demand Model II TSLS	Excess Demand Model II OLS	Capacity Model II TSLS	Capacity Model II OLS	Excess Demand Model II TSLS	Excess Demand Model II OLS	Capacity Model II TSLS	Capacity Model II OLS
Constant	—7.177	—5.928	—2.948	—3.061	—	—	—	—
		(5.210)						
p	1.319	1.297	1.537	1.488	1.135	1.075	1.397	1.326
	(14.470)	(18.767)	(20.588)	(27.896)	(9.858)	(13.435)	(9.585)	(15.757)
T	.315	.358	.103	.153	.488	.528	.278	.275
	(3.360)	(4.791)	(1.153)	(2.380)	(4.209)	(6.197)	(1.791)	(3.136)
p^*	.895	.834	.921	.906	.431	.395	.554	.522
	(4.594)	(5.071)	(5.329)	(7.005)	(2.252)	(2.631)	(2.614)	(3.574)
h	.922	.632			.979	.987		
	(2.267)	(2.453)			(2.113)	(3.450)		
$(N^d/N^s)_{-1}$			1.572	1.736			1.022	1.410
			(3.735)	(5.471)			(2.152)	(3.920)
S_1	.010	.004	.009	.007				
	(.952)	(.474)	(.999)	(1.004)				
S_2	.039	.033	.036	.037				
	(3.271)	(3.668)	(4.088)	(5.697)				
S_3	.046	.025	—.004	—.005				
	(1.642)	(1.353)	(.402)	(.699)				
R	.996	.997	.997	.998	.954	.972	.940	.971
$D—W$	.852	.809	1.208	1.097	.771	1.024	.827	.851

Table 10. Dependent variable: Wage rate ln w^r and change in wage rate Δ ln w^r

Independent variables	Estimates of regression coefficients					
	Untransformed equations (*ln*)			Transformed equations (Δ *ln*)		
	Excess Demand Model I TSLS	Excess Demand Model I OLS	Capacity Model I OLS	Excess Demand Model I TSLS	Excess Demand Model I OLS	Capacity Model I OLS
Constant	—3.045	—2.897	—.670	—	—	—
		(4.168)				
p_{-1}	.930	.932	1.047	.846	.833	.977
	(18.413)	(20.084)	(21.488)	(13.622)	(14.035)	(15.410)
T	.210	.211	.099	.276	.288	.144
	(3.888)	(4.116)	(1.676)	(4.142)	(4.546)	(2.192)
$\overset{*}{p}_{-1}$	.919	.916	.925	.659	.655	.738
	(8.374)	(8.781)	(8.671)	(5.978)	(6.176)	(7.115)
h	.521	.487		.369	.448	
	(2.411)	(3.092)		(1.381)	(2.154)	
$(N^d/N^s)_{-1}$			.764			.784
			(2.832)			(2.953)
S_1	.021	.020	.022			
	(3.116)	(3.229)	(3.410)			
S_2	.029	.028	.028			
	(4.423)	(4.817)	(4.678)			
S_3	.031	.029	.028			
	(2.271)	(2.706)	(1.072)			
R	.997	.998	.997	.938	.970	.974
$D—W$	1.846	2.001	1.960	1.854	2.064	1.832

Table 11. Dependent variable: Wage drift $ln(w^e/w^r)$ and change in wage drift $\Delta\ ln(w^e/w^r)$

Independent variables	Estimates of regression coefficients					
	Untransformed equations (*ln*)			Transformed equations (Δ *ln*)		
	Excess Demand Model I TSLS	Capacity Model I TSLS	Excess Demand/ Capacity Model I OLS	Excess Demand Model I TSLS	Capacity Model I TSLS	Excess Demand/ Capacity Model I OLS
Constant	—16.957	—12.103	—12.691	.020	.020	.020
h	3.664	2.613	2.743	.561	.546	.371
	(5.767)	(4.558)	(4.676)	(2.548)	(2.391)	(1.871)
N^d/N^s	3.562	5.071	4.124	.902	.807	.713
	(2.523)	(3.485)	(3.024)	(2.510)	(2.091)	(2.152)
S_1	.048	.042	.038			
	(2.289)	(1.814)	(1.593)			
S_2	.061	.035	.040			
	(2.491)	(1.394)	(1.539)			
S_3	.212	.141	.152			
	(4.539)	(3.218)	(3.423)			
R	.800	.744	.723	.481	.424	.359
D—W	.399	.571	.623	.993	.920	.970

Table 12. Dependent variable: Average number of hours worked ln h and change in average number of hours worked Δ ln h

Independent variables	Estimates of regression coefficients					
	Untransformed equations *(ln)*			Transformed equations *(Δ ln)*		
	Excess Demand Model I TSLS	Excess Demand Model II TSLS	Excess Demand Model I & II OLS	Excess Demand Model I TSLS	Excess Demand Model II TSLS	Excess Demand Model I & II OLS
Constant	4.038	3.971	4.132	—	—	—
N^d/N^s	—2.070	—2.557	—1.386	—.830	—.997	—.836
	(3.242)	(4.773)	(3.047)	(2.270)	(2.633)	(3.055)
$(Y^d/Y^s)_{-2}$	.383	.434	.313	.213	.229	.214
	(4.507)	(5.949)	(4.346)	(3.741)	(4.023)	(4.276)
T_t	.133	.149	.111			
	(5.378)	(7.043)	(5.480)			
S_1	—.042	—.047	—.035			
	(5.247)	(6.857)	(5.274)			
S_2	—.016	—.014	—0.17			
	(3.300)	(3.462)	(3.689)			
S_3	—.068	—.068	—.068			
	(14.582)	(16.460)	(14.445)			
R	.932	.947	.930	.499	.530	.567
$D—W$	1.278	1.559	1.365	1.325	1.385	1.281

Table 13. Dependent variable: Demand for labour ln N^d and change in demand for labour Δ ln N^d

Independent variables	Estimates of regression coefficients									
	Untransformed equations (*ln*)					Transformed equations (Δ *ln*)				
	Excess Demand Model I TSLS	Excess Demand Model II TSLS	Capacity Model I TSLS	Capacity Model II TSLS	Excess Demand/ Capacity Model I & II OLS	Excess Demand Model I TSLS	Excess Demand Model II TSLS	Capacity Model I TSLS	Capacity Model II TSLS	Excess Demand/ Capacity Model I & II OLS
Constant	3.825	3.881	3.783	3.840	3.887	—	—	—	—	—
					(19.469)					
Y	.479	.466	.489	.476	.462	.529	.483	.703	.608	.536
	(4.748)	(4.659)	(4.908)	(4.815)	(4.736)	(4.676)	(4.954)	(7.661)	(7.035)	(6.775)
w^e/p	—.106	—.083	—.123	—.100	—.080	—.083	—.121	—.349	—.204	—.094
	(1.460)	(1.264)	(1.720)	(1.541)	(1.360)	(.616)	(1.204)	(3.375)	(2.409)	(1.578)
T	—.313	—.311	—.314	—.312	—.309	—.371	—.356	—.426	—.396	—.371
	(2.597)	(2.566)	(2.636)	(2.604)	(2.567)	(4.063)	(3.964)	(5.430)	(4.795)	(4.377)
S_1	—.004	—.004	—.004	—.004	—.004					
	(.825)	(.815)	(.838)	(.826)	(.829)					
S_2	.024	.023	.024	.024	.023					
	(5.941)	(5.856)	(6.095)	(6.003)	(5.930)					
S_3	.043	.044	.043	.044	.044					
	(8.533)	(8.664)	(8.557)	(8.684)	(8.790)					
R	.972	.972	.973	.972	.976	.861	.860	.898	.882	.822
D—W	1.603	1.593	1.607	1.601	1.591	1.572	1.471	1.582	1.448	1.338

Table 14. Dependent variable: Supply of labour $ln\ N^s$ and change in supply of labour $\Delta\ ln\ N^s$

Independent variables	Estimates of regression coefficients									
	Untransformed equations *(ln)*					Transformed equations *(Δ ln)*				
	Excess Demand Model I TSLS	Excess Demand Model II TSLS	Capacity Model I TSLS	Capacity Model II TSLS	Excess Demand/ Capacity Model I & II OLS	Excess Demand Model I TSLS	Excess Demand Model II TSLS	Capacity Model I TSLS	Capacity Model II TSLS	Excess Demand/ Capacity Model I & II OLS
Constant	2.829	2.896	2.362	2.578	2.242	—	—	—	—	—
					(2.832					
V	.383	.369	.485	.438	.511	.351	.287	.757	.604	.700
	(1.375)	(1.759)	(1.733)	(2.079)	(2.971)	(1.226)	(1.277)	(2.893)	(2.803)	(4.331)
w^e/p	.087	.094	.035	.059	.026	.110	.142	—.096	—.185	—.067
	(.617)	(.896)	(.249)	(.559)	(.304)	(.804)	(1.375)	(.776)	(.189)	(1.005)
$(Y^d/Y^s)_{-2}$	.099	.098	.103	.101	.107	.081	.073	.130	.111	.123
	(1.954)	(1.975)	(2.024)	(2.015)	(2.090)	(1.658)	(1.688)	(2.784)	(2.573)	(3.130)
S_1	—.006	—.006	—.006	—.006	—.006					
	(1.392)	(1.437)	(1.360)	(1.437)	(1.161)					
S_2	.018	.017	.019	.018	.019					
	(3.636)	(3.881)	(3.815)	(3.998)	(4.230)					
S_3	.037	.037	.036	.036	.036					
	(7.854)	(8.247)	(7.667)	(8.082)	(8.229)					
R	.954	.954	.953	.954	.962	.725	.736	.727	.719	.750
$D—W$	1.416	1.390	1.450	1.425	1.451	1.495	1.525	1.525	1.555	1.239

APPENDIX II

Diagrams of Estimates, Transformed Excess Demand Model I

Figures 6—11 are graphical representations of the equations in Transformed Excess Demand Model I simultaneously estimated.

In the top panel of each figure, the observed and computed values of the variable to be explained, are compared. The contributions of each of the explanatory variables to the total explanation are shown in the lower panels. The lowest panel shows the residuals which are, in fact, the differences between the observed and computed values of the variables in the top panel.

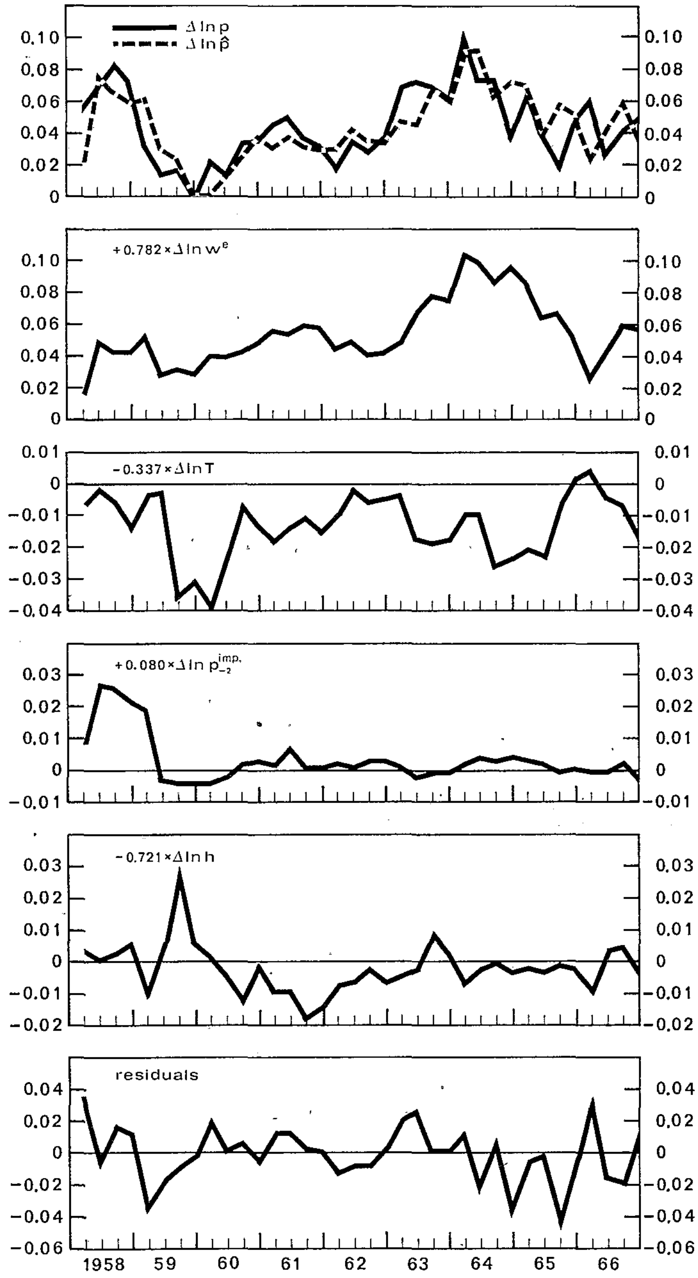

Figure 6. Price equation

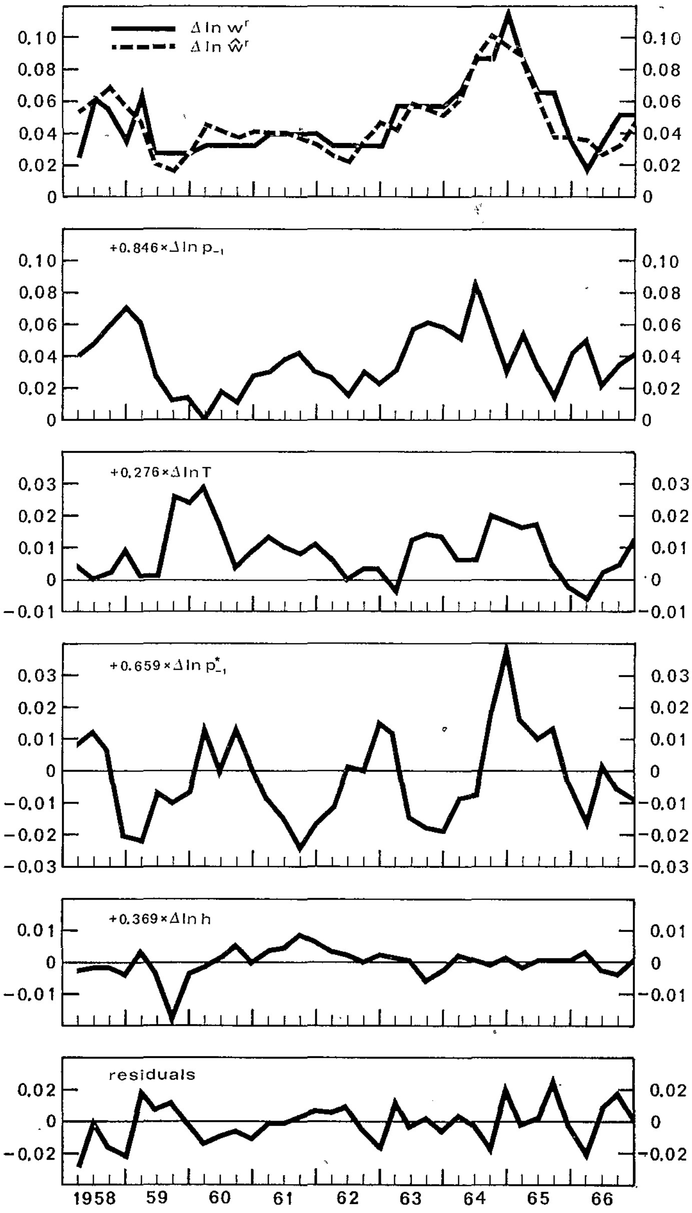

Figure 7. Wage rate equation

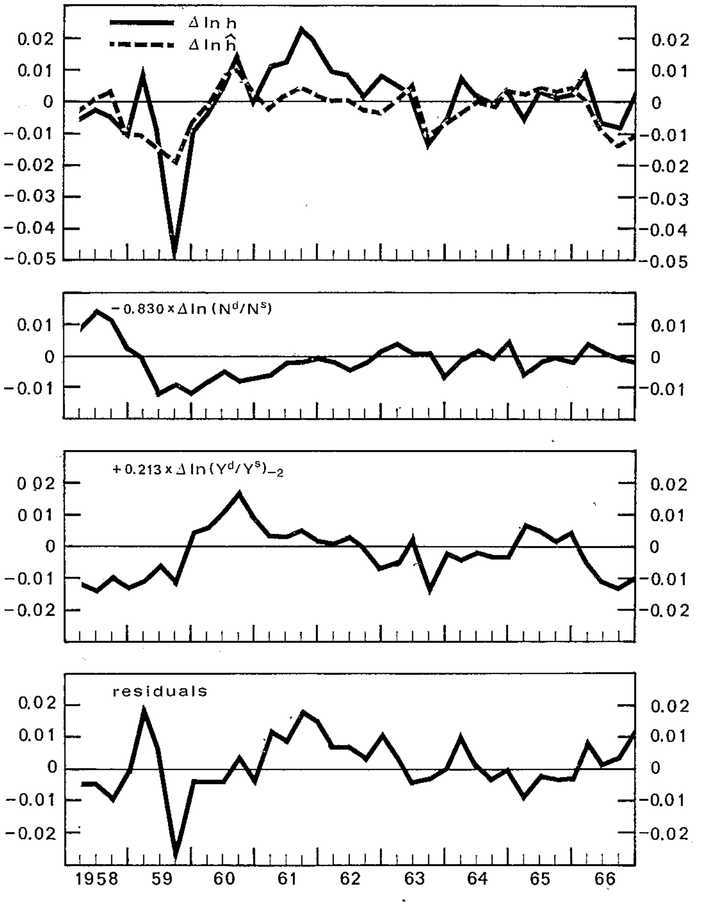

Figure 8. Activity equation

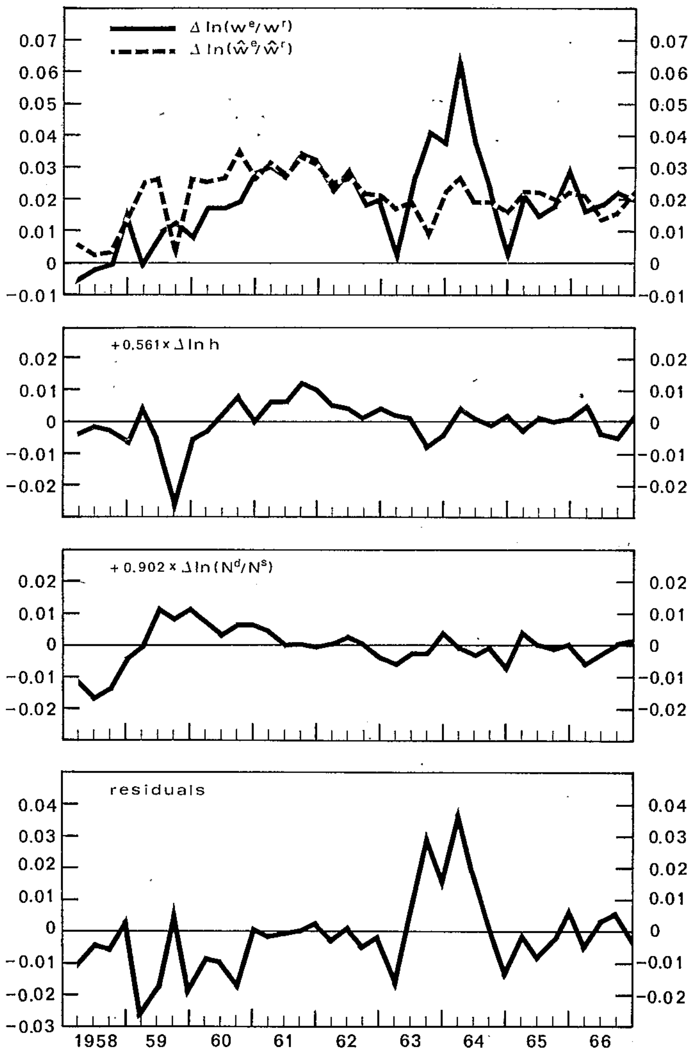

Figure 9. Wage drift equation

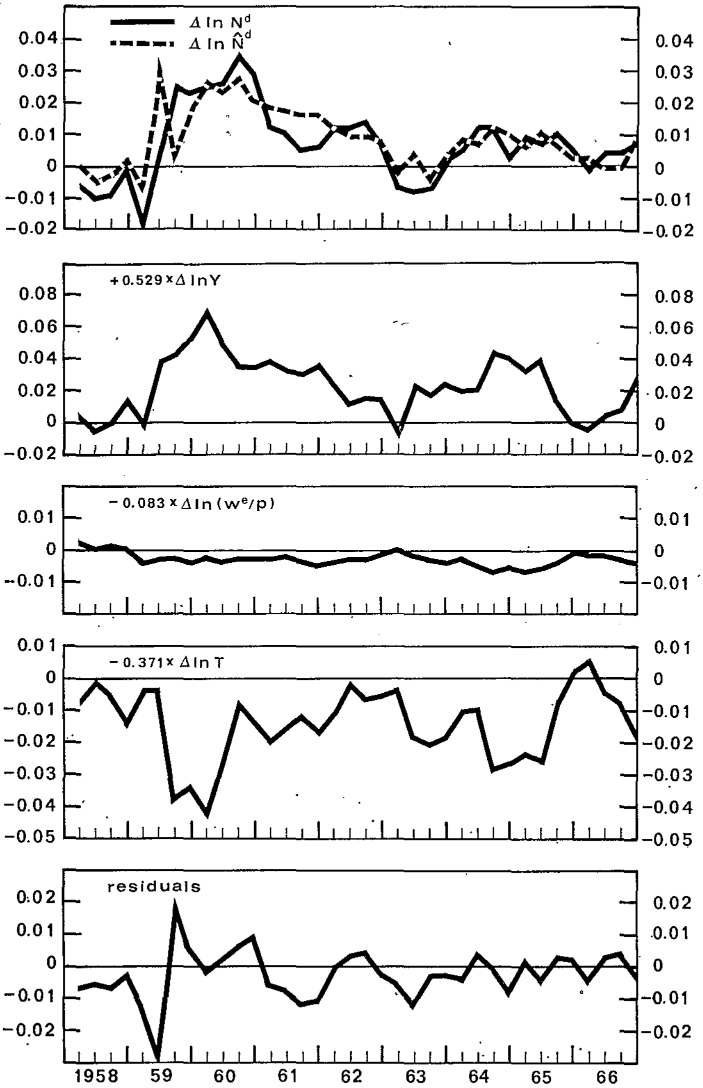

Figure 10. Demand for labour equation

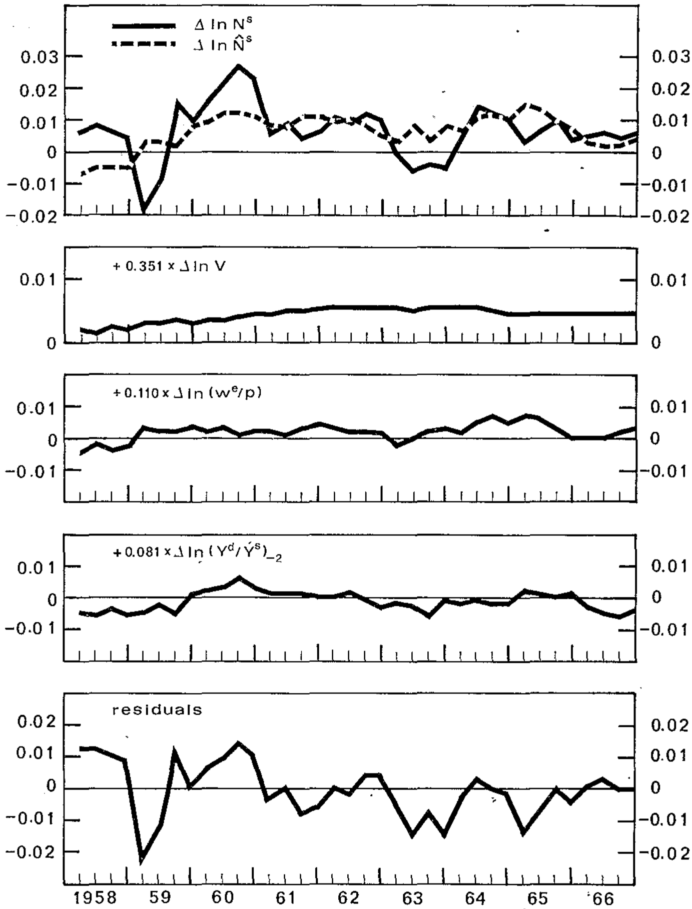

Figure 11. Supply of labour equation

APPENDIX III

Operational Counterparts of the Variables Used in the Empirical Analysis, Statistical Sources and Numerical Data.

Appendix III. A. Operational Counterparts of the Variables Used in the Empirical Analysis and Statistical Sources.

Appendix III. B. Numerical Data.

APPENDIX III. A. OPERATIONAL COUNTERPARTS OF THE VARIABLES USED IN THE EMPIRICAL ANALYSIS AND STATISTICAL SOURCES

p = Price level, as measured by the ratio of the value of gross domestic product at factor cost at current prices to its value at constant prices (= the implicit price index of the gross domestic product). The constant-price time series was obtained by linking together two separate series. The observations up to 1964 are based on a series the weighting pattern of which is from the year 1954, and those for 1965—66 on a series with a weighting pattern from the year 1964.[1]

w^e = Earnings level, as measured by the level of earnings index for all wage and salary earners. The time series employed was obtained by linking together two separate series, with weights from 1954 and 1964 respectively.[1]

w^r = Level of negotiated wage rates, the operational counterpart of which was constructed on the basis of those increases in wage rates that were introduced through collective agreements for certain key industries and sectors. According to the available information, the following negotiated increases were introduced during the sample period: 3 per cent at the beginning of 1957; 4 per cent at the beginning of April 1958; 3 per cent at the beginning of 1959; 3.5 per cent at the beginning of 1960; 4.3 per cent at the beginning of 1961; 3.5 per cent at the beginning of 1962; 6 per cent at the beginning of 1963; 6 per cent at the beginning of 1964; 3.1 per cent at the beginning of March 1964; 3.1 per cent at the beginning of October 1964; 3.8 per cent at the beginning of 1965; 3 per cent at the beginning of February 1966; and 2.4 per cent at the beginning of June 1966. The increases introduced in April 1958, March 1964 and October 1964 were effected to compensate wage and salary earners for increases in the cost of living index in conformity with the collective agreements in force. The Central Statistical Office of Finland has published an index describing the movement of negotiated wage rates since 1962. This index and the index constructed here have behaved quite uniformly.[2]

w^e/w^r = Wage drift, which has been measured here by means of the ratio of

1. Source: *National Accounting in Finland in 1948—1946* and *Bulletin of Statistics*, No. 10, 1967, both published by the Central Statistical Office of Finland.

2. The index of negotiated wage rates constructed by the Central Statistical Office of Finland has been published in *Palkkatilasto (Wage and Salary Statistics)* No. 1, 1968, issued by the office.

the earnings index of wage and salary recipients to the index of negotiated wage rates constructed for this study.

p^e = Cost of living index, which was obtained by linking together the two official cost-of-living index series available, with weights from (October) 1951 and (the fourth quarter of) 1957.[3]

p^* = Deviation of the cost of living from the general price level, as measured by the ratio of the cost of living index to the implicit price index of gross domestic product.

w^e/p = Real earnings level, as measured by the ratio of the earnings level index for wage and salary recipients to the implicit price index of gross domestic product.

p^i = Import prices, as measured by the unit value index of total merchandise imports. The index employed was obtained by weighting together two indices with 1954 and 1962 used respectively as base years.[4]

p^{ir} = Unit value index of raw material imports. The index was obtained by linking together two indices, with 1954 and 1962 respectively as the base years.[4]

p^{ii} = Unit value index of investment goods imports. The index was obtained by linking together two indices, with 1954 and 1962 respectively as base years.[4]

p^{imp} = $.61\ p^{ir} + .39\ p^{ii}$, the weights employed being proportional to the shares of raw materials and investment goods in the total value of raw material and investment goods imports in 1962.

N^d = Demand for labour, as measured by the number employed according to the current labour force sample surveys. (Since the supply of labour exceeded the demand for it throughout the sample period, it was legitimate to employ an indicator of realized employment as the empirical counterpart of the demand for labour variable.)[5]

3. Source: *Bulletin of Statistics*, 1956—1967, published by the Central Statistical Office of Finland.

4. Source: *Foreign Trade, Monthly Bulletin*, 1957—1967, published by the Statistical Bureau of the Board of Customs.

5. Source: *Labour Reports*, published by the Ministry of Communications and Public Works (Employed Persons according to Labour Force Sample Survey). The figures for 1956 and 1957 were obtained by means of the year-to-year changes in the employment figures calculated by the Central Statistical Office of Finland; to convert these into quarterly figures, use was made of seasonal indices based on the seasonal distribution of the Labour Force Sample Survey figures for 1958.

N^s = Supply of labour, as measured by the number of those in labour force according to the Labour Force Sample Survey.[6]

N^e = Labour input according to the Labour Force Sample Survey series.[7]

V = Population of working age according to the relevant Labour Force Sample Survey series.[8]

Y = Value of gross domestic product at factor cost at constant prices (= volume of gross domestic product). The index employed was obtained by linking together two time series, with weighting patterns from the years 1954 and 1964 respectively.[9]

Y^d/Y^s = Excess demand in the commodity market, as measured by the ratio of realized output to its own exponential trend.

T = Productivity of labour, as measured by the ratio of the volume of gross domestic product to the total labour input series of the Labour Force Sample Survey.

h = Average hours worked, as measured by the ratio between the Labour Force Sample Survey series of total labour input and the number employed.

6. Source: *Labour Reports,* published by the Ministry of Communications and Public Works (Total Labour Force according to Labour Force Sample Survey). The quarterly figures for 1956 and 1957 were obtained by assuming that the changes from 1956 to 1957 and from 1957 to 1958 were the same as that from 1958 to 1959 and by employing the seasonal distribution for 1958.

7. Source: *Labour Reports,* published by the Ministry of Communications and Public Works (Labour Input according to Labour Force Sample Survey). The figures for 1956 and 1957 were obtained by employing the seasonal distribution for 1957 and the year-to-year changes from 1956 to 1957 and from 1957 to 1958 in the labour input series of the Central Statistical Office.

8. Source: *Labour Reports,* published by the Ministry of Communications and Public Works (Population 15 years and over). In the estimation of the figures for 1957, the seasonal distribution in 1958 and the change in the number of persons in the age group 15 to 64 between 1957 and 1958, according to the annual statistics of the Central Statistical Office, were used.

9. This series was also used in the computation of the operational counterpart of the price level variable p.

APPENDIX III. B. NUMERICAL DATA, 1958 = 100

Year	Quarter	p	p^*	w^e	w^r	w^e/w^r	w^e/p
1956	I						
	II						
	III	92.3	98.0	93.2			
	IV	90.3	100.6	93.2			
1957	I	90.7	100.4	94.0	94.7	99.3	103.6
	II	92.1	100.3	94.7	94.7	100.0	102.8
	III	94.5	100.4	95.7	95.5	100.2	101.3
	IV	94.8	102.0	96.2	97.1	99.1	101.5
1958	I	96.1	102.5	96.0	97.1	98.9	99.9
	II	99.0	101.4	100.9	101.0	99.9	101.9
	III	102.9	97.5	101.2	101.0	100.2	98.3
	IV	102.0	98.8	101.8	101.0	100.8	99.8
1959	I	99.3	101.6	102.9	104.0	98.9	103.6
	II	100.6	100.1	104.9	104.0	100.9	104.3
	III	104.8	96.6	105.5	104.0	101.4	100.7
	IV	102.2	101.1	105.8	104.0	101.7	103.5
1960	I	101.7	102.0	108.4	107.6	100.7	106.6
	II	102.2	102.3	110.5	107.6	102.7	108.1
	III	108.5	97.0	111.4	107.6	103.5	102.7
	IV	106.0	99.0	112.7	107.6	104.7	106.3
1961	I	106.6	99.8	116.6	112.2	103.9	109.4
	II	107.7	98.8	118.5	112.2	105.6	110.0
	III	112.6	94.6	120.3	112.2	107.2	106.8
	IV	109.5	98.3	121.5	112.2	108.3	111.0
1962	I	108.9	100.1	123.6	116.1	106.5	113.5
	II	111.8	98.9	126.4	116.1	108.9	113.1
	III	116.0	96.9	126.9	116.1	109.3	109.4
	IV	113.8	100.0	128.4	116.1	110.6	112.8
1963	I	116.8	97.9	131.6	123.1	106.9	112.7
	II	120.4	96.3	137.8	123.1	111.9	114.5
	III	124.5	94.2	140.3	123.1	114.0	112.7
	IV	121.3	98.8	141.6	123.1	115.0	116.7
1964	I	129.8	96.9	150.6	131.8	114.3	116.0
	II	129.8	99.2	156.7	134.6	116.4	120.7
	III	129.8	100.2	157.1	134.6	116.7	121.0
	IV	129.8	101.3	160.3	138.7	115.6	123.5
1965	I	135.2	98.5	168.4	144.0	116.9	124.6
	II	132.8	101.4	170.3	144.0	118.3	128.2
	III	136.7	99.6	171.3	144.0	119.0	125.3
	IV	138.2	99.1	171.6	144.0	119.2	124.2
1966	I	139.3	98.9	174.8	147.0	118.9	125.5
	II	138.8	100.6	180.3	149.6	120.5	129.9
	III	143.9	98.3	185.0	152.0	121.7	128.6
	IV	144.0	99.5	185.0	152.0	121.7	128.5

APPENDIX III. B. (continued) NUMERICAL DATA, 1958=100

Year	Quarter	p^i	p^{ir}	p^{ii}	p^{imp}	Y	N^d	N^s	N^d/N^s
1956	I					90.3			
	II					97.2			
	III		75.6	64.5	71.3	101.7	99.8	96.9	103.0
	IV		77.0	64.5	72.1	97.3	103.3	98.9	104.4
1957	I	80.0	78.5	67.9	74.4	101.4	100.3	99.3	101.0
	II	82.1	80.7	67.2	75.4	98.0	101.9	100.1	101.8
	III	83.6	85.2	69.3	79.0	101.3	101.9	100.1	101.8
	IV	102.9	105.2	94.4	101.0	96.2	98.0	97.7	100.3
1958	I	104.3	105.2	97.8	102.3	102.3	99.8	100.0	99.8
	II	100.7	100.0	99.2	99.7	97.2	101.0	101.0	100.0
	III	98.6	98.5	103.2	100.3	101.5	101.1	100.8	100.3
	IV	97.1	96.3	99.8	97.7	99.0	98.1	98.2	99.9
1959	I	96.4	96.3	98.5	97.2	102.5	98.1	98.3	99.8
	II	95.0	92.6	99.2	95.2	104.6	101.6	100.3	101.3
	III	95.0	94.1	98.5	95.8	110.3	103.8	102.5	101.3
	IV	94.3	93.3	97.8	95.1	109.8	100.5	99.3	101.2
1960	I	97.9	98.5	101.2	99.6	117.1	100.7	100.0	100.7
	II	96.4	97.0	102.5	99.1	115.2	104.4	102.6	101.8
	III	95.0	98.5	96.4	97.7	118.3	107.6	105.4	102.1
	IV	98.6	100.7	107.3	103.3	117.6	103.6	101.6	102.0
1961	I	97.9	97.8	103.9	100.2	126.3	102.0	100.7	101.3
	II	97.9	95.6	106.6	99.9	122.8	105.5	103.6	101.8
	III	96.9	96.3	106.6	100.3	125.6	108.2	105.9	102.2
	IV	97.9	95.6	118.2	104.4	126.0	104.3	102.3	102.0
1962	I	99.8	96.3	114.8	103.5	132.6	103.3	101.9	101.4
	II	98.9	95.6	117.5	104.1	125.8	106.9	104.6	102.2
	III	97.9	93.3	115.4	101.9	129.8	109.8	107.3	102.3
	IV	98.9	93.3	114.8	101.7	129.7	105.1	103.4	101.6
1963	I	98.9	93.9	116.6	102.8	131.5	102.7	101.9	100.8
	II	99.8	95.8	113.1	102.5	131.6	106.2	104.1	102.0
	III	99.8	96.7	116.6	104.5	134.6	109.2	107.0	102.1
	IV	101.8	96.7	122.4	106.7	136.9	105.3	103.0	102.2
1964	I	101.8	99.6	117.8	106.7	136.8	103.3	102.5	100.8
	II	101.8	101.5	116.6	107.3	137.2	107.6	105.7	101.8
	III	101.8	102.4	117.8	108.4	146.9	110.6	108.4	102.0
	IV	102.8	99.6	123.5	108.9	146.9	105.7	104.1	101.5
1965	I	102.8	99.6	117.8	106.7	146.2	104.3	102.9	101.4
	II	102.8	99.6	122.4	108.5	148.3	108.5	106.5	101.9
	III	102.8	99.6	122.4	108.5	151.4	111.8	109.6	102.0
	IV	102.8	98.6	123.5	108.3	147.1	106.3	104.6	101.6
1966	I	104.8	99.6	129.3	111.2	145.3	104.3	103.5	100.8
	II	102.8	97.7	120.1	106.4	149.9	109.0	107.2	101.7
	III	101.8	98.6	125.8	111.5	154.1	112.4	110.1	102.1
	IV	102.8	96.7	131.6	112.1	155.8	107.2	105.3	101.8

APPENDIX III. B. (continued) NUMERICAL DATA, 1958=100

Year	Quarter	V	N^e	T	h
1956	I				
	II				
	III		103.1	98.6	
	IV		104.3	93.2	
1957	I	98.9	100.2	101.2	99.9
	II	99.3	102.2	95.9	100.3
	III	99.3	100.6	100.7	98.7
	IV	99.7	101.0	95.2	103.1
1958	I	99.6	99.2	103.1	99.4
	II	99.9	101.1	96.1	100.1
	III	100.1	99.4	102.1	98.3
	IV	100.4	100.3	98.7	102.2
1959	I	100.6	98.6	104.0	100.5
	II	100.9	100.8	103.8	99.2
	III	101.2	97.8	112.8	94.2
	IV	101.4	101.8	107.9	101.3
1960	I	101.8	100.9	116.1	100.2
	II	102.1	104.1	110.7	99.7
	III	102.5	103.0	114.9	95.7
	IV	102.9	105.2	111.8	101.5
1961	I	103.2	103.4	122.1	101.4
	II	103.7	106.6	115.2	101.0
	III	104.1	106.0	118.5	98.0
	IV	104.6	108.0	116.7	103.5
1962	I	105.0	105.8	125.3	102.4
	II	105.5	108.9	115.5	101.9
	III	105.9	107.9	120.3	98.3
	IV	106.4	109.7	118.2	104.4
1963	I	106.8	105.8	124.3	103.0
	II	107.2	108.5	121.3	102.2
	III	107.7	106.0	127.0	97.1
	IV	108.2	109.4	124.2	103.9
1964	I	108.6	107.3	127.5	103.9
	II	109.0	110.3	124.4	102.5
	III	109.4	107.4	136.8	97.1
	IV	109.8	110.4	133.1	104.4
1965	I	110.1	107.9	135.5	103.5
	II	110.5	111.6	132.9	102.9
	III	110.9	108.8	139.2	97.3
	IV	111.3	111.3	132.2	104.7
1966	I	111.7	109.1	133.2	104.6
	II	112.1	111.5	134.4	102.3
	III	112.5	108.6	141.9	96.6
	IV	112.8	112.6	138.4	105.0

APPENDIX IV

Correlation Matrix of Variables in Transformed Excess Demand and Capacity Models

(correlation coefficients are based on the logarithmic differences between the variables)

	p	p_{-1}	w^e	w^e/p	w^r	w^e/w^r	T	N^d	N^s	N^d/N^s	Y	$(Y^d/Y^s)_{-2}$	h	V	p^{imp}_{-2}	p^*_{-1}	$(N^d/N^s)_{-1}$	p^*
p	1.000																	
p_{-1}	.930	1.000																
w^e	.925	.924	1.000															
w^e/p	.545	.648	.823	1.000														
w^r	.909	.914	.978	.780	1.000													
w^e/w^r	.821	.806	.896	.749	.784	1.000												
T	.589	.629	.746	.766	.737	.652	1.000											
N^d	.319	.299	.494	.615	.426	.567	.669	1.000										
N^s	.528	.465	.603	.540	.570	.584	.598	.885	1.000									
N^d/N^s	–.219	–.149	.285	.391	–.596	.213	.405	.606	.168	1.000								
Y	.597	.624	.779	.824	.746	.731	.958	.802	.734	.454	1.000							
$(Y^d/Y^s)_{-2}$	–.305	–.317	–.122	.188	–.177	.167	–.340	.489	.285	.532	.196	1.000						
h	.157	.154	.204	.216	.162	.264	–.156	.293	.112	–.126	.725	.429	1.000					
V	.882	.878	.952	.781	.910	.898	.734	.581	.665	.104	.797	–.813	.238	1.000				
p^{imp}_{-2}	.546	.557	.372	.394	.451	.146	.972	–.142	.165	.587	.644	–.448	.930	.287	1.000			
p^*_{-1}	–.469	–.194	–.192	.278	.998	–.272	.973	.137	.277	–.196	.308	.201	–.526	–.798	.976	1.000		
$(N^d/N^s)_{-1}$	–.269	–.269	–.308	.335	–.109	.143	.185	.478	.191	.686	.278	.538	.604	.188	–.550	–.684	1.000	
p^*	–.194	–.856	–.107	.266	.600	–.161	.806	.210	.253	.117	.111	.150	–.422	–.491	–.155	.575	.241	1.000

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Abbreviations of Journal Titles:

Am. Econ. Rev.	=	American Economic Review
Econ. Jour.	=	Economic Journal
Int. Econ. Rev.	=	International Economic Review
KAK	=	Kansantaloudellinen aikakauskirja
Oxf. Econ. Papers	=	Oxford Economic Papers
Rev. Econ.Stat.	=	Review of Economics and Statistics
Rev. Econ.Stud.	=	Review of Economic Studies