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URBANIZATION AND INDUSTRIALIZATION: MODELING SWEDISH DEMOECONOMIC DEVELOPMENT FROM 1870 TO 1914

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FOREWORD

Roughly 1.6 billion people, 40 percent of the world's population, live in urban areas today. At the beginning of the last century, the urban population of the world totaled only 25 million. According to recent United Nations estimates, about 3.1 billion people, twice today's urban population, will be living in urban areas by the year 2000.

Scholars and policy makers often disagree when it comes to evaluating the desirability of current rapid rates of urban growth and urbanization in many parts of the globe. Some see this trend as fostering national processes of socioeconomic development, particularly in the poorer and rapidly urbanizing countries of the Third World; whereas others believe the consequences to be largely undesirable and argue that such urban growth should be slowed down.

This paper describes the urbanization and development experience of Sweden during the years 1870-1914. A general equilibrium demoeconomic model is outlined which seeks to capture characteristics specific to the Swedish situation. Following a number of earlier papers on the Mexican and Polish case studies, Urban Karlström's analysis of Swedish development further expands the collection of national case studies that are envisioned as part of the Population, Resources, and Growth Task.

A list of the papers in the Population, Resources, and Growth Series appears at the end of this paper.

Andrei Rogers
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ABSTRACT

Rapid urbanization in developing countries today has increased the interest in the historical experiences of developed countries. Through a case study on Sweden, it is hoped that further insights will be gained about the complex interaction of economic and demographic variables during a country's industrialization phase.

This paper presents the model which will be used for an analysis of Swedish demoeconomic development. This general equilibrium model has been designed to capture specific Swedish characteristics, especially the extent and pattern of foreign trade and emigration which have been given an explicit treatment and a crucial role in the model. The analysis of these aspects will be carried out through counterfactual simulations for the 1870-1914 period.

CONTENTS

URBANIZATION AND INDUSTRIALIZATION: MODELING SWEDISH DEMOECONOMIC DEVELOPMENT FROM 1870 TO 1914

INTRODUCTION

One of the most challenging problems in Third World countries is the very rapid growth of metropolitan areas. The two most important questions are: is urbanization a necessary and desirable consequence of the process of development, or is it a constraint on further development? In order to understand the interaction between economic growth and urbanization in the developing world today there has been increasing interest in the analysis of the historical experiences of developed countries. This is the purpose of the Swedish case study. Through an analysis of the crucial factors in Swedish demoeconomic development, it is hoped that further insights into the interactions of economic and demographic variables can be gained.

This study covers the prewar period, 1870-1914. The principle of period division follows the conventional view where the 1870s is considered as the starting decade for the industrialization in Sweden, and a dramatic political event, the outbreak of the First World War is picked as the terminal year (Heckscher, 1957). But, to consider 1914 as a watershed terminal year seems reasonable even from economic points of view: the war caused dramatic changes on the world market which positively influenced the conditions for industrialization in Sweden. One of the most striking of these was the change in Sweden from a dependence on the importation of foreign capital to a capital exporting nation. Moreover, a second dramatic change was the end of the great migration to America. The migration period started in the 1860s and was thus a rather dominant factor during Sweden's industrialization. For an examination of the industrial breakthrough in Sweden, see Gårdlund (1942), Jörberg (1961, 1970), and Montgomery (1947).

The First World War is, therefore, the terminal point of this study. The influence that the war had on Sweden's demoeconomic development is not our concern here, the 44 years between 1870 and 1914 are challenging enough as a subject of study.

During these 44 years the per capita income grew showing an annual growth rate of two percent (derived from Appendix II.2). Compared with other countries the Swedish (per capita) growth rate was among the highest in the world. Only Japan and the United States showed a more rapid rate of per capita growth. But as Kuznets pointed out, it was the rather low increase in the population that gave Sweden its leading position (Kuznets, 1965:13). The Swedish population grew from almost 4.2 million in 1870 to slightly more than 5.6 million at the outbreak of the war, showing an annual growth rate of 0.7 percent (derived from Appendix II.1). During the same time emigration drained the population of roughly 1.1 million people, thus explaining the rather low rate of population growth.

Not only the demographic but also the economic consequences of the emigration were far reaching. It has been regarded as beneficial through its increasing effect on real wages even though it is rather difficult to estimate its total consequences on the economy (Henricsson, 1969). Internal migration was also considerable during this period and is reflected to some extent in the rate of urbanization.* It increased from 13 percent to 31 percent between 1870 and 1914. This reallocation of the labor force from

*Urbanization refers to the proportion of population living in towns and cities, see page 29.

a low productivity agricultural sector to a modern industrial sector with higher productivity contributed positively to the economic growth. These gains in labor force reallocation have been estimated and the result can be seen in Tables II.3 and II.4 in Appendix II. Nearly 24 percent of the productivity increase can be explained by urbanization. The gains differ between different decades but the most important appear during the 1880s.*

These general remarks on the Swedish development show how interrelated demographic and economic variables are. The interplay between them is especially important in a study highlighting the urbanization process during the industrialization of a country. Migration, perhaps one of the most significant links between demography and economics, shows clearly the existence of causality in both directions.

This has implications for the methodology chosen for this study. In many migration studies one underlying assumption is that

> .....while the various explanatory factors influence migration, migration does not in turn influence these factors. If this assumption does not in fact hold, the parameter estimates of the various models posses a simultaneous equations bias that may be great enough to vitiate the findings (Greenwood, 1975:412).

When one considers how important economic variables (for example wages) seem to be in the migration decision, and how the reallocation of the labor force between sectors works as an equilibrating factor on wages, one must take a general equilibrium approach to the problem. Only within such a framework can the complicated relations between the various demographic and economic variables be satisfactorily analyzed (Rogers, 1977).

Thus the model that this paper deals with is of the general equilibrium type. It is within the tradition of the so-called MSG models, multisectoral growth models, first developed by Leif Johansen (see, for example, his revised book on the subject from

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*Åberg calculated almost the same figures using older data (Åberg, 1969).

1974) and later extended by Bergman, among others (Bergman, 1978; Bergman and Pőr. 1980). The models also draw from the theory of dualistic economic growth formulated in a general equilibrium framework by Kelley and Williamson (Kelley, Williamson, and Cheetham, 1973; Kelley and Williamson, 1974, 1979).

This general equilibrium model is designed for the Swedish prewar development for the purpose of undertaking counterfactual analysis. If the actual demoeconomic development between 1870 and 1914 can be described in the simulations of the model, it is possible to undertake counterfactual studies. Through changes of some exogenous variables or parameters in the model the importance of the variable and the interdependence in the economy can be explored through a comparison between the actual development and the counterfactual history. The following aspects will be analyzed:

1. What role did emigration play? Its consequences have been discussed since Wicksell pointed out in the 1880s that emigration solved the proletarization problem in Swedish agriculture (Wicksell, 1882). But what were the long-run consequences of emigration? Should a larger population have increased the economic growth because of its enlargement of the home market? Was emigration a substitute for internal migration?

2. How crucial was the growth of world trade and changes in terms of trade for the performance of economic growth? Were the trade tariffs stipulated in the 1880s important for the development of the Swedish consumer-goods industry? What was the impact of the participation of the agricultural sector in foreign trade on the outmigration from the rural areas?

3. Was the import of foreign capital a prerequisite for economic growth? What would have been the consequences to industrial growth and urbanization if there had been more borrowing? Was the saving generated in the agricultural sector to any substantial extent transferred to industry or was it absorbed by the investments within the sector?

4. How important was capital formation and technical progress in agriculture to the development of incomes? And moreover, what effect did capital formation have on outmigration and urbanization?

5. How important to growth was the increasing internal demand? How did differences in consumption patterns between rural and urban households influence industrial growth?

The list of questions can easily be prolonged. These and other aspects of the Swedish development will be analyzed with the help of the model. The study may not only be of some historical interest but it is hoped that it may also increase our understanding of the forces behind the urbanization process as well as its implications in a small and open economy such as Sweden.

THE SECTOR DIVISION

The structure of the model is based on the duality between a traditional agricultural sector and a more modern industrial sector. But in order to capture the specific mechanisms that have driven the economic growth it is necessary to extend the model beyond the simple two-sector analysis. Therefore, the industrial sector has been divided into four different sectors.*

The five production sectors and their empirical counterparts can be seen in Table 1. The rationale for this division is based on the relationship of each sector to the world market because of the importance of foreign trade on Swedish economic growth. Exports are seen as the driving force in the economic development of Sweden (Jörberg, 1961; Ohlsson, 1969). The rising share of export in the GNP indicates this. Export amounted to 19 percent of GNP in 1871-1875, to 22 percent in 1891-1895, and 24 percent in 1911-1915 (see Table 2). The industrial sectors have been divided into three groups according to their dependence on foreign trade: export-oriented industries, homemarket-oriented industries, and branches of industries sheltered from international competition. Table 2 also shows exports and imports in relation to gross

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*Agricultural activities are treated within one sector in the model. For a discussion of subsectors see Colosio (1979).

Table 1. The production sectors in the model and their empirical counterparts.

Subscripts	Sector[a]
1	Agriculture, forestry, and fishing
2	Export-oriented industry (mining and metal, wood products, pulp, paper and printing, food products)
3	Homemarket-oriented industry (textile and clothing, leather, hair and rubber, chemical industries, power station, water and gas works, stone, clay, and glass)
4	Service (commerce and other services, public administration, transport and communication, services of dwellings)
5	Building and construction

[a] Sectors 2-5 are sometimes treated as one group, the urban sector (U), in contrast with the agriculture sector (A).

production in the various sectors, the main criteria for the groups of the sectors, and in the economy as a whole. The strategic role that building and construction activities have played in the economy has motivated a division of the trade sheltered sector into a service sector, and a building and construction sector. The major function of the building industry is investment in railways and housing, both of which have played a crucial role in the Swedish development. When it is important, however, to stress the dualism between agriculture and industry, the four nonagricultural sectors are treated as one sector and called the urban sector.

PRODUCTION AND TECHNOLOGY

The dualism between agriculture and industry during the 19th century was to a large extent a question of differences in production conditions which result in a much lower productivity within the agricultural sector than the industrial sector.

Table 2. Export and import by sector.

Model Sector	Sector	Export Share EX_i/EX			Export Ratio EX_i/gross[a] output			Import Share IM_i/IM			Import Ratio IM_i/gross[a] output		
		71/75	91/95	11/15	71/75	91/95	11/15	71/75	91/95	11/15	71/75	91/95	11/15
1.	Agriculture, forestry & fishing	22	10	4	8	4	3	27	27	28	9	12	16
2.	Mining & Metal	21	14	22	38	27	34	12	12	17	22	22	22
	Wood products	27	28	17	80	71	59	1	1	1	3	2	3
	Pulp, paper and printing	2	5	14	33	51	59	1	2	1	17	17	4
	Food products	4	16	10	6	17	13	26	15	12	35	17	13
3.	Textiles and clothing	1	2	1	4	8	6	20	18	10	86	72	33
	Leather, hair & rubber	--	1	--	--	6	10	2	4	4	25	39	24
	Chemical industries	2	3	4	16	27	26	7	11	13	56	86	100
	Power stations, water and gas works	--	--	--	--	--	--	--	--	--	--	--	--
	Stone, clay and glass	1	3	3	14	41	23	7	10	14	229	120	110
4.	Commerce and other services	6	7	8	5	4	8	--	--	--	--	--	--
	Public administration	--	--	--	--	--	--	--	--	--	--	--	--
	Transport & communication	14	14	15	58	43	41	--	--	--	--	--	--
	Services of dwellings	--	--	--	--	--	--	--	--	--	--	--	--
5.	Building & construction	--	--	--	--	--	--	--	--	--	--	--	--
		100	100	100	19	22	24[b]	100	100	100	19	22	21[b]

[a] Gross output is the domestic production of commodity i, including intermediate goods

[b] Total exports and total imports as shares of gross domestic production

Source: Johansson (1967)

The sources of productivity growth are not exactly the same in agriculture as in industry. In agriculture productivity can be divided into two parts

$$\frac{X}{L} \equiv \left(\frac{X}{R}\right)\left(\frac{R}{L}\right)$$

where $\frac{X}{L}$ is agricultural output per worker in the sector, $\frac{X}{R}$ is output per acreage, and $\frac{R}{L}$ is land per worker. The identity clarifies that an increase in output per worker can come about through an improved yield per unit of land, through a larger area per worker, or through a combination of both.

Between 1870 and 1912 the output per worker grew at an annual rate of 1.19 percent, of this growth 62 percent came from an increase in output per acreage (at an average rate of 0.74 percent per year) and the rest came from increase in *land per worker* (at an annual growth rate of 0.45 percent).* In the 1880s the labor force started to decline, but cultivated acreage increased during the whole prewar period. Holgersson has estimated the growth to be 12-15 percent between 1870 and 1914.

From these figures it is obvious that the reclamation of land was important for the development of agriculture. Moreover, it is worth noting that reclamation of land and increases in productivity had gone on for a long time before industrialization began and was a consequence of the growth in population.

During the 100-year period between 1750 and 1850, the net population increase was 1.3 million. Roughly 80 percent of the population was dependent on agriculture, and since the rate did not change during that period, slightly more than one million people were absorbed by the agricultural sector. Through increased acreage of cultivatable land and increased productivity

*The figures underlying the estimates are taken from the following sources: *output:* Kratz and Nilsson 1975:172; *employment:* Jungenfelt 1966:224; and *cultivated acreage:* Holgersson 1974:47. The new data for cultivated acreage which has been estimated by Holgersson indicates that the agricultural output is ten percent too low in the 1860s (see Kratz and Nilsson 1975:35). Therefore, we have used figures for X in 1870 that have been increased by ten percent.

due to new techniques and land reform, the agricultural sector managed to absorb its growing population (Thomas, 1941:49). However, this trend did not continue after 1850.

The population pressure on the agriculture increased during the second part of the century with a natural population growth higher than before during the 1870s and 1880s. Despite productivity increases the agricultural sector was no longer totally able to absorb the growing population. The growth in productivity in agriculture during the prewar period was a consequence of not only increased acreage of cultivatable land. The growth of output per acre that occurred stresses the importance of technological development and capital increase. The combine-harvester is an example of how production technology has become more and more capital intensive.

This means that with the three factors of production—land, labor, and capital—the conventional production functions are not appropriate if one is not able to justify a constant elasticity of substitution between each pair of production factors. Instead of assuming such a constancy, a so-called nested production function is used. Labor and capital are seen as functionally separable from land. This means that growth in cultivated land carried a proportional increase in the marginal productivity of labor and capital.* Labor and capital are combined in a constant-elasticity-of-substitution (CES) production function into a composite production factor (H). H and land are then combined in a Cobb-Douglas function. There is some empirical support for not choosing a Cobb-Douglas specification for labor and capital. In a study by Jungenfelt (1966), it is shown that labor's share of value-added in agriculture decreased before the First World War (see Table 3). Jungenfelt has also estimated the elasticity of substitution between labor and capital to be 0.6.** Thus a Cobb-Douglas specification for these two production factors is inappropriate.

*For a discussion of the specification of production-technology in agriculture see Kaneda (1979:11).
**See Jungenfelt (1966:22). These estimates cover the whole period 1870-1950, but to our knowledge they are the only ones available that cover the prewar period.

Table 3. The labor share, 1870-1914.

Period	The whole economy	Agriculture	Industry	Transport
1870-79	72	84	67	41
1880-89	72	82	75	46
1890-99	70	83	71	43
1900-09	66	80	63	45
1910-14	64	75	60	47

Source: Jungenfelt 1966:42.

The CES production function is used for each nonagricultural sector. Even in these sectors, the development of the labor share of value added and the elasticity of substitution have been the base on which the choice has been made. As can be seen in the table neither the transport nor the industry exhibits constant shares. It is true that the sectors in the model differ from Jungenfelt's displayed in Table 3, but the model sectors 2 and 3—the export-oriented and the homemarket-oriented industries—compose Jungenfelt's industry sector and his transport sector forms an increasing part (six percent in 1871-75 and 17 percent in 1911-15) of model sector 4, the service sector. The elasticities of substitution in industry and transport are estimated to be 0.6 (Jungenfelt, 1966:202).

The production functions in the model have thus the following form.* For agriculture:

$$X_1 = A\, R^{\alpha}\, H^{1-\alpha} \tag{5}$$

$$H = \left\{ \delta_1 \left(g_1\, K_1 \right)^{-\rho_1} + \gamma_1 \left(h_1\, L_1 \right)^{-\rho_1} \right\}^{-\frac{1}{\rho_1}} \tag{6}$$

*The complete mathematical statement of the model can be found in Appendix I. Equation numbers correspond with the mathematical statement.

and for the remaining four sectors

$$X_j = \left\{ \delta_j \left(g_1 \; K_j \right)^{-\rho_j} + \gamma_j \left(h_j \; L_j \right)^{-\rho_j} \right\}^{-\frac{1}{\rho_j}} \qquad (7)$$

$$j = 2,\ldots,5$$

$$X_{ij} = a_{ij} \; X_j \qquad i = 1,\ldots,5 \quad j = 1,\ldots,5 \qquad (8)$$

X_j are gross output in sector j, K_j the capital stock and L_j the employment in sector j. A is the efficiency parameter in the agricultural production function, and can be interpreted as an indicator of the state of the technology. α, δ_j and γ_j are distribution parameters. The formulation allows for differnet values of these parameters in the different sectors. The substitution parameter is ρ, and it is defined as

$$\rho = \frac{1}{\varepsilon_s} - 1$$

where ε_s is the elasticity of substitution. The technological parameters are g_j and h_j, and $g_j \; K_j$ and $h_j \; L_j$ can be referred to as "efficiency capital" and "efficiency labor", respectively.

Technological development is one of the dynamic features of the model. There is historical evidence of its large growth-creating effect. Åberg has estimated that 42 percent of the growth in productivity between 1870 and 1913 is explained by technological progress (Åberg, 1969:38). It is also shown that the growth in technology was not neutral but labor-saving (Jungenfelt, 1966; Åberg, 1969). Moreover, the labor saving bias was not only a characteristic for the industry sectors but also for agriculture.

The model formulation captures these characteristics. The technological parameters in the production functions, A, g_j, h_j, change over time (t) according to exogenously determined growth rates:

$$A(t) = A(t-1)\ e^{\lambda_1} \tag{52}$$

$$g_j(t) = g_j(t-1)\ e^{\lambda_j^g} \tag{53}$$

$$h_j(t) = h_j(t-1)\ e^{\lambda_j^h} \tag{54}$$

The growth rate λ differs among the different sectors and when $\lambda_h > \lambda_g$ the model exhibits a labor saving bias in technological growth.

Reflecting the historical situation, the area of cultivated land is enlarged over time in the model:

$$R(t) = R(t-1)\ e^{r} \tag{51}$$

where r is the annual rate of growth in land acreage.

The different factors of production are assumed to be combined in such a way that the profit is maximized in each sector. Before the necessary conditions are presented it is worthwhile to point out three specific features of the model.

(1) Because of lower agricultural wages, a reallocation of the labor force from agriculture to other sectors took place. But, as can be seen in Figure 1, the wages were not equalized during this period. For a discussion of the sectorial wages see Bagge, Lundberg, and Svennilson (1933). In a pure general equilibrium model, the labor force is allocated in each period of time in such a way that the wages are equalized if no wage structure or inertia is built into the model. It is thus necessary in an equilibrium model, with the purpose of highlighting the urbanization process, to prolong the equilibrating process, i.e., to build in some disequilibrating mechanism. In this model it is done through the specification of an explicitly formulated migration function. As will be discussed later, migration is a function of the wage relationship among different sectors. Thus there will be a reallocation of labor among the sectors through migration, but not to such an extent that wages will be equalized in each period of time.

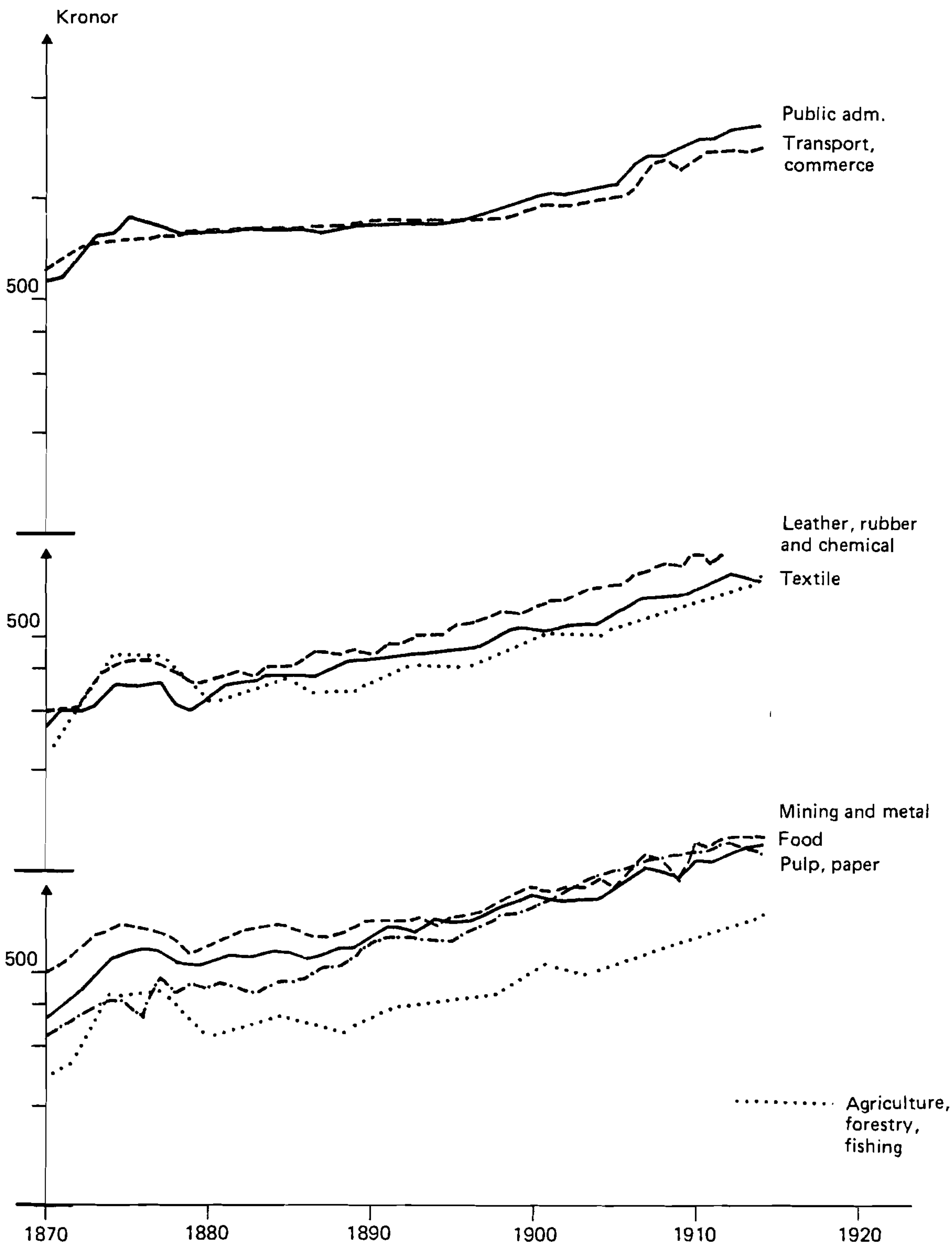

Figure 1. Wages in different sectors, 1870-1914.
Source: Jungenfelt, 1966.

(2) The stock of capital is exogenously determined in the agricultural and in the urban sectors as a whole. The reason for this allocation of capital is that no efficient capital market existed at that time (see p. 26), so one can assume that capital was not allocated efficiently over all the sectors of the economy, especially not between agriculture and the rest of the sectors. Among the urban sectors in the model capital is allocated according to differences in the rate of returns.

(3) There are three sets of prices in the model. P_i are the domestic production costs, and P_i^D are the domestic prices of commodity i which are distinguished from the domestic production costs through the influence of the world market in the three sectors where foreign trade occurs.*

$$P_i^D = \frac{im_i}{1 + im_i} (1 + \phi_i) P_i^W + \frac{1}{1 + im_i} P_i \qquad (1)$$

$$i = 1,3$$

where im_i is the share of import in sector i, see p. 23, ϕ_i is an *ad valorem* custom duty on imports, and P_i^W are world market prices. The export-oriented sector is assumed to be a price taker on the world market. The world market price has a total price penetration on the Swedish market. Thus the domestic price in sector 2 is exogenous in the model:

$$P_2^D = \bar{P}_2^W \qquad (2)$$

And in sectors 4 and 5—service, and building and construction—there is no foreign trade so no differences will occur between domestic production costs and domestic prices:

$$P_i^D = P_i \qquad i = 4,5 \qquad (3)$$

*The treatment of the foreign trade is more fully discussed on p. 21, as well as in Bergman and Pőr (1980).

The third set of prices in the model is introduced to simplify the treatment of intermediary goods. A set of so-called value added prices, P_j^*, is defined as the production cost on one unit of a commodity after deduction of the cost for the necessary intermediaries to produce that commodity:

$$P_j^* = P_i - \sum_{j=1}^{5} P_j^D a_{ji} \qquad j = i = 1,\dots,5 \tag{4}$$

With these three basic features of the model in mind, the necessary conditions for profit maximization can be presented. First we have the agricultural sector. Because capital stock and available land are exogenous, the profit function is formulated as:

$$\Pi_1 = P_1^* X_1 - W_1 L_1 \tag{10}$$

where Π_1 is profit in agriculture and W_1 the wage rate. Included in Π_1 are not only remittances to the owners of capital and land, but also the necessary depreciation of the capital stock. Labor is paid in correspondance with its marginal productivity and this results in the following conditions for profit maximization:

$$\frac{W_1 L_1}{P_1^* X_1} = (1 - \alpha) \gamma_1 \left[\frac{H}{h_1 L_1}\right]^{\rho} \tag{9}$$

In the four urban sectors profit is defined as

$$\Pi_i = P_i^* X_i - W_i L_i - RC_i (P_2^D K_i^M + P_5^D K_i^B)$$

$$- \left[P_5^D \kappa^B \zeta_i + P_2^D \kappa^M (1 - \zeta_i)\right] K_i$$

From the "revenues" $P_i^* X_i$ [observe that the cost for intermediary goods has already been deducted, see equation (4)], the total wage sum ($W_i L_i$), the returns on the capital stock (RC_i), and depreciation are deducted. The capital stock is divided into buildings, B, and other capital equipment M. κ^B, κ^M are the annual rate of depreciation of buildings and plants, and the rest of the capital stock. The share of buildings and plants out of the total capital stock in sector i is ζ_i. If the concept "user cost" of capital, Q_i, (Johansen, 1974) is defined as:

$$Q_i = P_2^D (RC_i + \kappa^M)(1 - \zeta_i) + P_2^D (RC_i + \kappa^B) \zeta_i \qquad (10a)$$

$$i = 2,...,5$$

then the profit function can be rewritten as:

$$\Pi_i = P_i^* X_i - W_i L_i - Q_i K_i$$

The resulting necessary conditions derived from this profit function are:

$$\frac{W_j L_j}{P_j^* X_j} = \gamma_j \left[\frac{X_j}{h_j L_j}\right]^{\rho_j} \qquad j = 2,...,5 \qquad (11)$$

$$\frac{Q_j K_j}{P_j^* X_j} = \delta_j \left[\frac{X_j}{g_j K_j}\right]^{\rho_j} \qquad j = 2,...,5 \qquad (12)$$

The export sector is supposed to be the sector that leads the way in wages. The wage increases in that sector are followed by increases in other urban sectors and results in a rather fixed wage structure over time. Different wages over time, plotted in Figure 1 seem to justify such an assumption. The wages in the industry branches that form sector 2, are rather close to each other and are also higher than in the homemarket-oriented sectors. However, the public administration and the transport subsector have the highest wages. This may be explained by a higher share of skilled labor in these sectors. The fluctuations in the wages also seem to support the hypothesis that the export sector is wage determining.

The fixed relationships among the urban sectors are built into the model through equation (14):

$$W_j = \omega_j W_u \qquad j = 2,\ldots,5 \qquad (14)$$

where ω_j are the constants and W_u is a variable defined as equal to unity in the base year. ω_j is, therefore, the wage rate at the base point of time.

With equation (14) there will be a different wage rate in each one of the urban sectors and the supply of labor in the urban sector will be allocated so that this relationship prevails over time. The allocation of the capital stock, which is exogenously determined for the urban sector, is determined in the same way:

$$RC_j = q_j RC_u \qquad j = 2,\ldots,5 \qquad (13)$$

The constants are q_j, and RC_u is a variable defined as unity in the initial year, and q_j are, therefore, the rates of return in the four urban sectors in the base year.

THE FACTOR MARKET

Different characteristics of the factor markets have been discussed in the previous sections. It is enough just to present the equations which close the labor and the capital markets. The supply of labor is a function of the population in the agricultural (N_1) and urban (N_u) areas:

$$L_1 = p_1 N_1 \qquad (15)$$

$$L_u = p_u N_u \qquad (16)$$

p_1 being the participation rate. In a study by Silenstam the development of the labor participation rate during the prewar period is discussed. He found that the rate increased for both men and women during the prewar period: from 79.7 percent in 1870 to 88 percent in 1910 for men above the age of 15, and from 18.9 percent in 1870 to 21.2 percent in 1910 for women. Therefore, the participation rate in the model is not a fixed parameter but an exogenous variable which increases over time (Silenstam, 1970:102).

The employment in the different urban sectors have to add up to the supply of the labor in these sectors (L_u):

$$\sum_{j=2}^{5} L_j = L_u \tag{17}$$

The population grows through migration as well as natural increase and migration is a function of the relative wages between agriculture and industries. The labor supply in the urban sector is, through migration, sensitive to relative wage differences and the labor supply curve thus slopes upward.

The capital stock in the different urban sectors has to add up to the total capital stock available to them, K_u:

$$\sum_{j=2}^{5} K_j = K_u \tag{18}$$

HOUSEHOLD DEMAND AND INCOME

Consumption demand and its pattern has long been suppressed in the explanation of the long-run economic growth process, at least in theoretical studies. The supply condition has always been the primary focus. In different empirical studies, however, the importance of the final demand and its structure has been stressed (Kelley, 1968, 1969).

In a simple two sector simulation model by Kelley, Williamson, and Cheetham, the effect on the growth process from the demand side was analyzed. The conclusion was that

> .....demand does play a pervasive and important role in the model through changes in consumer tastes. Indeed, in a simulation experiment we find that the sensitivity of the economy to shifts in tastes toward urban goods may be as stimulatory to structural change in the long run as alterations in savings parameters, the variable of traditional focus in the development literature. Thus, the "demonstration effect," commonly a villain in descriptive analyses of growth and development, may turn out to be as much a hero as the touted puritan ethic regarding high savings and spending prudence (Kelley, Williamson, and Cheetham, 1974: 241).

Did demand play a similar role in the Swedish development? In the simulations of the model this question can be answered. From different studies it is clear that there has been a shift in the consumption patterns. In a study of the cost of living in Sweden, 1860-1930, Myrdal composed two typical household budgets, one for the middle and one for the end of the 19th century (Myrdal, 1933:116, 138). He found that during this time the consumption pattern changed considerably. For example, the share of the family income spent on food decreased from 65 to 55 percent. In a study by Allen (1955:91) comparing household budgets for industrial and agricultural workers for the year 1913/14, the same conclusion was drawn. As expected, the share of food expenditure was highest among the lower paid rural workers. These changes in budget shares for different types of commodities are due to both price and income-effects. Changes in relative prices affects the allocation of expenditure. When the per capita income grows, the marginal increase in demand for luxuries (industrial goods) is larger than that for necessities (agricultural goods). This so-called Engel effect has been a typical feature of the growth process in various types of countries on different development levels (Houthakker, 1957), and Sweden is no exception (Parks, 1969:648). The typical relationship between income elasticities of different commodities seems to be that the income elasticity for primary products is lower than for industrial goods, which is lower than for services.

Besides these demand structure characteristics, duality in the demand pattern is sometimes stressed (Kelley, Williamson, and Cheetham (1972:76). The consumers in the urban areas disclose another consumption pattern than the population in the traditional agricultural sector. Thus urbanization also plays an important indirect role in the development process through its influence on the pattern of final demand.

Against this background the household demand in the model is captured by two expenditure systems, one for the urban areas (U) and one for the agricultural areas (A). The selected form is the Linear Expenditure System (LES).*

$$P_i^D D_{ij} = b_{ij} P_i^D + \beta_{ij} \left(C_j - \sum_{i=1}^{5} b_{ij} P_i^D \right) \qquad i = 1,\ldots,5 \quad j = A,U \tag{19}$$

$$C_j = (1 - s^l) Y_j^{Dl} + (1 - s^c) Y_j^{Dc} \qquad j = A,U \tag{20}$$

where D_{ij} is consumption of commodity i in sector j, b_{ij} is a parameter which can be seen as the subsistence consumption of commodity i in sector j, and β_{ij} stands for the marginal propensity to consume commodities after subsistence expenditures are satisfied. The consumption expenditure C_j is the remaining disposable income after deduction for savings. Different savings rates (s^l, s^c) are assumed for labor and capital income.

In equations (21)-(24), the disposable incomes are defined. The tax rate, τ, differs between labor and capital incomes.

$$Y_A^{Dl} = (1 - \tau^l) Y_A^l = (1 - \tau^l) W_1 L_1 + RE \tag{21}$$

Besides income from wages, the agricultural labor force receives remittances from emigrants (RE). These incomes have often been neglected in studies of this period, but they are of a substantial magnitude. The amount fluctuates around an average of one

*A detailed treatment of LES can be found in Powell (1974) where the derivation from the underlying utility functions is also discussed.

percent of the Swedish national product (Lindahl, Dahlgren, and Koch, 1937:588). In the model it is assumed that these remittances are sent to people living in the rural areas since these are the main origins of the emigrants. The remittances are exogenously determined in the model. The capital income in the agricultural sector

$$Y_A^{Dc} = (1 - \tau^c)\ Y_A^c = (1 - \tau^c)\ \Pi_1 \tag{22}$$

consists of income from land and capital. In the urban sector, labor income comes only from employment in industries:

$$Y_U^{Dl} = (1 - \tau^l)\ Y_U^l = (1 - \tau^l) \sum_{j=2}^{5} W_j\ L_j \tag{23}$$

and capital income comes from returns on capital investments

$$Y_U^{Dc} = (1 - \tau^c)\ Y_U^c = (1 - \tau^c) \sum_{j=2}^{5} Q_j\ K_j \tag{24}$$

EXPORTS AND IMPORTS

As has already been pointed out in the discussion on the sectoral division in the model, exports have played a crucial role in Swedish economic development. The effect on economic growth have been along two lines, through an increase in the demand of Swedish products and through an increase in productivity because of competition with foreign supply.

The effects on economic growth were rather important during the Swedish prewar period. Ohlsson (1969:60) has estimated that the direct and indirect effects of foreign trade have contributed to 56 percent of the growth in the national product between 1870 and 1890 and to 29 percent between 1890 and 1913. He also concluded that a large part of the technical progress made during this time can be explained by foreign trade through its positive effect on productivity.

These stimulating effects on the Swedish economy, made possible by a quick adaptation to new world market conditions, altered the structure of the Swedish foreign trade.

> At the outbreak of the First World War, about one third of Sweden's exports consisted of goods that 25 years earlier had not, broadly speaking, existed in the Swedish export statistics. The expansive powers in the exports had thereby been usurped by quite other groups of goods than earlier (Fridlizius, 1963:30).

Two characteristic features of this structural change should be stressed:

(1) The decline in agricultural exports, as shown in Table 2. In the 1870s, agricultural exports made up more than 20 percent of Sweden's total exports. Oats were the most important export product until 1890 when butter took this position. The stagnation in grain exports was due to sharpened competition. (Russia and America became strong competitors because of improved transportation facilities.) Toward the end of the century grain exports almost ended.

(2) The change from raw material exports (iron ore and timber) to more manufactured products. Iron ore had been the traditional Swedish export for a long time, technical innovations and organization changes, however, altered its structure. The old mining areas in central Sweden began to concentrate on manufactured products and the phosphorus iron ore in the North became worth mining. Furthermore, in the 1890s, the engineering industry started to expand on the basis of two early Swedish innovations: the separator an original Swedish invention, and the telephone. Also the timber industry began to reflect the typical export pattern—a transition to manufactured products. In the 1880s this industry held a 43 percent share of the world market but this share decreased considerably by the end of the 1890s. During the same period, however, the pulp and paper industry began to expand. The increase in world trade, as well as the development of productivity and production costs in Sweden, in relation to the rest of the world, has been pointed out as the determining factors behind the growth of Swedish exports (Ohlsson, 1969:83).

These factors are thus included as export-determining factors in the model. As can be seen in the trade statistics (Table 2), exports have occurred in all of the three model sectors that have participated in foreign trade. The model also allows for this. In sectors 1 and 3, the agricultural sector and the home-market sector, the export functions have an indentical formulation:

$$EX_i = EX_i^o \left(\frac{P_i}{P_i^w} \right)^{\varepsilon_i} e^{\sigma_i t} \qquad i = 1,3 \qquad (25)$$

Exports from sector i, EX_i, are determined by the relation between Swedish production costs P_i and the world market prices P_i^w, as well as the growth of the world market, σ. The price elasticity parameter, ε_i, captures the response between changes in relative prices and exports, EX^o, being constant. All the Swedish main export industries are put together into one sector in the model: sector 2—the export-oriented industry. Thus one feature of the Swedish export pattern cannot be caught in the model, the transition from raw material exports to the export of manufactured products.* More than three fourths of industrial exports are covered by sector 2. In 1899, the total share of industry products in the world market was 0.97 percent and in 1913 1.25 percent (Ohlsson, 1969:79). It seems reasonable to assume from this that the export industry was a price-taker in the world market and that these products sold at world market prices in the home market (i.e., $P_2^D = P_2^w$). The export-limiting factor is, therefore, the growth of the capacity of the industry (i.e., the productivity increases and capital-formation). Against this background the export function cannot be of the same type as it is for sectors 1 and 3. Instead the exports from sector 2 are determined as a residual in the balance of payments. This means, for instance, that the capacity growth of the export industry will implicitly be the limiting factor of exports through the development of other economic variables in the model:

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*We have not divided this sector into a base industry sector and a refining industry sector in order to capture this transition because, to our knowledge, the necessary data are not available.

$$P_2\ EX_2 = P_1^W\ IM_1 + P_2^W\ IM_2 + P_3^W\ IM_3 - P_1\ EX_1$$

$$- P_3\ EX_3 - F - RE \qquad (28)$$

where IM is import, F net capital inflow from abroad, and RE remittances.

Imports were also concentrated in a few products as were exports. But as the economy grew imports became more and more diversified (see Table 2). The main import groups were agricultural products (more than 25 percent of imports during the entire period), food products, and textile and clothing. As can also be seen in Table 2, imports prevailed in all of the sectors open to foreign trade. Therefore, specific import functions have been formulated for each one of the sectors. In order to allow for both exports and imports in each of the three model sectors, one has to assume a finite elasticity of substitution between domestically produced commodities and those supplied by foreign producers. The domestic supply of a commodity is thus the sum of imports and domestic output less exports. The proportion is determined by:

$$im_i \equiv \frac{IM_i}{X_i - EX_i} = im_i^o \left(\frac{P_i}{(1 + \phi_i)\ P_i^W} \right)^{\mu_i} \qquad i = 1,3 \qquad (26)$$

The import share is not only a constant, im_i^o, but also a function of the relationship between domestic production cost and world market prices (plus any custom duty, ϕ, that may occur), and where μ_i is the price elasticity parameter.

Since no price differences, by assumption, exist in sector 2, prices cannot have an impact on the import share. Instead it is assumed, in correspondance with the figures in Table 2, p. 7, that the share diminishes over time:

$$im_2 \equiv \frac{IM_2}{X_2 - EX_2} = im_2^o\ e^{-\psi t} \qquad (27)$$

SAVINGS AND INVESTMENT

Domestic savings displayed two different tendencies during the 1870-1914 period, as can be seen in Figure 2. During the 1870s and the 1880s, the savings rate diminished from almost 11 percent to around seven percent. The rate showed a rapid increase, however, at the beginning of the 1890s.

The investment rate exhibited a similar pattern, but the reduction in the 1870s and 1880s was not as pronounced as the decline in the savings rate. The difference between these two concepts is the net capital borrowing from abroad (when the investment rate is higher than the savings rate). From Figure 2 it is obvious that there was an important inflow of foreign capital to Sweden during the industrialization period. The borrowing from abroad, mainly from France, was undertaken primarily by the government (Sundbom, 1944). Economic historians have found that foreign capital played a crucial role in Sweden's economic development process. Through capital inflow Sweden was able to build "cities, railways, and factories at the same time" (Gårdlund, 1942:194). Therefore, the investment in the infrastructure (housing and transportation) made up over 50 percent of the total investments during the prewar period. The housing share fluctuated between 30-40 percent and investment in transportation was around 20 percent. Industry's share increased from 16 percent in the 1970s to 25 percent before the First World War and agricultural investments declined from 22 percent to nine percent of the total investment (Lundberg, 1969:142).

During the beginning of the industrial era hardly any financial market existed. The need of industrial capital was to a great extent met by internal sources through retained profits, and the external credit facilities were mainly supplied by private persons with a close connection to the companies.* Toward the end of the century private banks became more and more important as collectors of private savings and suppliers of credit. The growth of financial intermediaries made the capital market more efficient, but nevertheless by the end of the period, the market was far from being described as an efficient market. Thus

*For a description of the financing of the Swedish industry during the industrial breakthrough, see Gårdlund (1947).

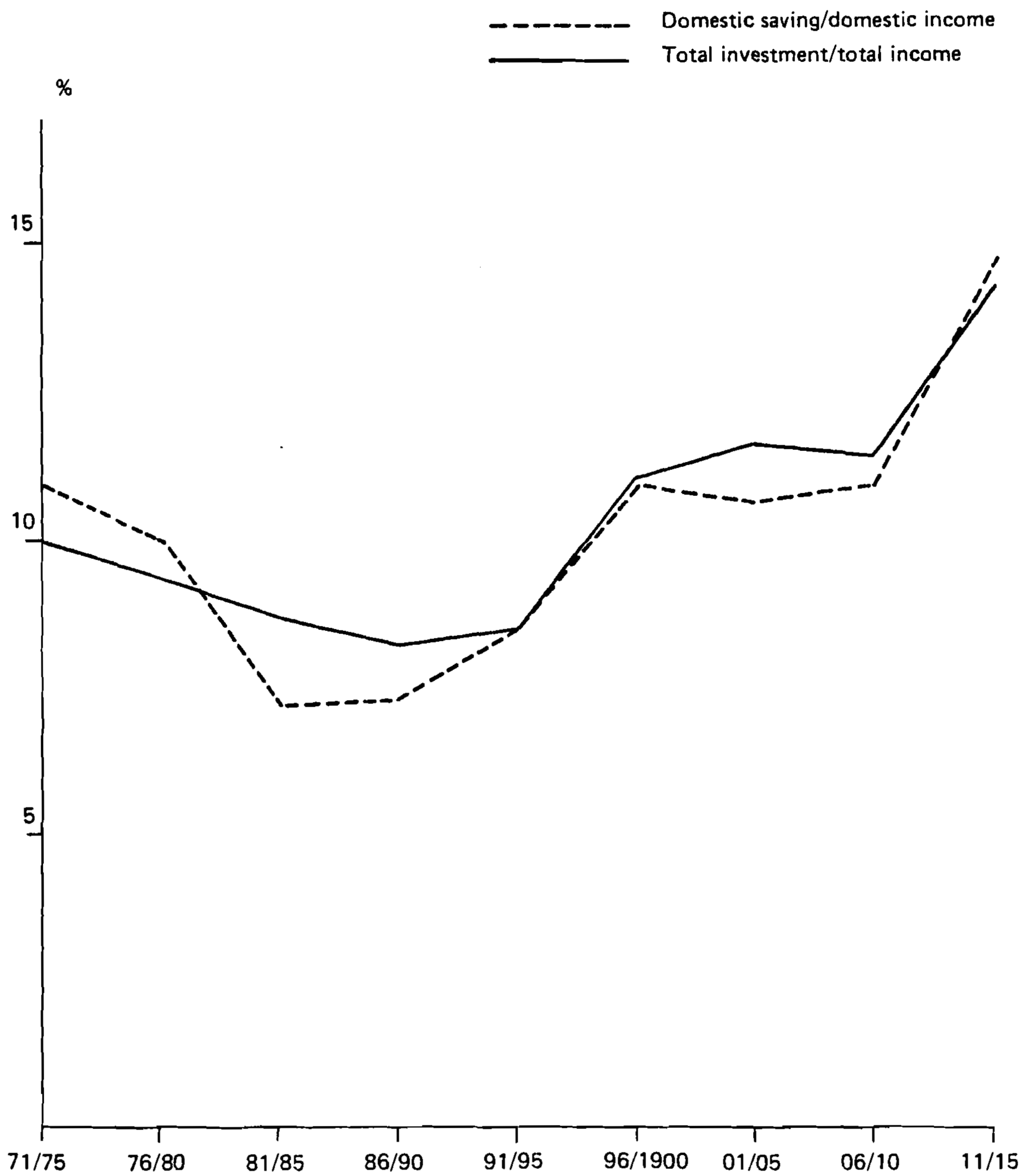

Figure 2. Savings and investment rate, 1870-1914.

Source: Kratz and Nilsson (1975) Table 2.2.3.

capital formation in Sweden was characterized by large government investment, foreign borrowing, and a growing but imperfect financial market.

Therefore, to include an allocation mechanism in the model which efficiently allocates the capital so that differentials in rate of returns between all sectors are obliterated seems to be an incorrect way to describe the actual situation. The ideal model formulation is, of course, to fomalize this imperfect capital market and to endogenize capital formation. But, at this stage a simpler treatment is chosen as previously described.

Capital is exogenously given to agricultural and urban sectors. Capital stock consists of buildings and plants, K_j^B, and other capital equipment K_j^M. This stock changes over time due to exogenously determined gross investments in the agricultural and urban sectors. As previously stated, the capital stock is divided among the urban sectors according to differences in costs of capital in such a way as to maintain a specific relationship (see equation 13).

$$K_j = K_j(t-1) + I_j(t-1) - \left[\kappa^B \zeta_j + \kappa^M (1 - \zeta_j)\right] K_j \qquad j = A,U \qquad (48)$$

where κ^B and κ^M are the different depreciation rates and ζ_j is the share of buildings and plants out of the total capital stock.

Investment (I) is divided into two types of physical capital which exist in the model. This is because they are produced in two different sectors: buildings and plant equipment are produced in sector 5 and the remaining physical capital is produced in sector 2.

$$I_1^B = \zeta_1 \; I_1 \qquad (33)$$

$$I_1^M = (1 - \zeta_1) \; I_1 \qquad (34)$$

$$I_u^B = \zeta_u \; I_u \qquad (35)$$

$$I_u^M = (1 - \zeta) \; I_u \qquad (36)$$

Savings originate from two different sources: private saving and government saving. Private savings are derived from labor and capital incomes in both agricultural and urban sectors:

$$S_A = s^l Y_A^{Dl} + s^c Y_A^{Dc} \tag{29}$$

$$S_U = s^l Y_U^{Dl} + s^c Y_U^{Dc} \tag{30}$$

$$S^P = S_A + S_U \tag{31}$$

where s^l and s^c are the shares of savings out of labor and capital incomes, and S^P are the total private savings. Furthermore, saving is also undertaken by the government and its savings S^G, are what remains after the governmental expenditures C^G are deducted from its income which originates from three sources, taxes on wages and capital incomes, custom duties, and foreign borrowing:

$$S^G = \sum_{j=1}^{5} \tau^l Y_j^l + \sum_{j=1}^{5} \tau^c Y_j^c + \sum_{i=1}^{3} \phi_i P_i^W IM_i + F - C^G \tag{32}$$

Government spending is an exogenous variable. Total savings in the model, which is endogenous except for foreign borrowing, has to add up to the total exogenous investment:

$$S^P + S^G = I_1 + I_u$$

MIGRATION

As has already been pointed out, the differences in economic forces between the agricultural sector, and the more modern industrial sectors, caused a reallocation of the most mobile production factor: the labor force. The migration was stimulated by industrialization and a strong relationship can be seen between the increase in migration and the industrial breakthrough.

Swedish migration began during the second part of the 19th century. Until the 1840s Sweden had been a rather static society with little and well regulated migration. In the 1840s the urban share of the total population was around ten percent, as it had been for decades (Öhngren, 1977:265). But at the end of the decade the urbanization rate started to increase, slowly but definitively. Still, in the 1870s, only slightly more than 13 percent of the population lived in towns and municipal communities, but 40 years later the urban population had increased to 30 percent.*

However, at this point, it is necessary to notice one specific feature of Swedish industrialization; namely, that the industries, to a great extent, were located in rural areas and not in towns and cities (Population Movements and Industrialization, 1941). Especially the industries that initiated the new epoch, wood, mining and metal industries, can be characterized as rural industries. Table 4 displays the percent of industrial workers in rural industries in 1876 and in 1913. In 1896, almost 67 percent of all industrial workers were employed in rural areas. The figure decreased to 58 percent in 1913. This decrease not only reflects the fact that urban industries had increased their employment share but also points to a typical feature of the Swedish urbanization process—the creation of new and larger towns. This phenomenon occurred through the growth of population agglomerations around rural industries, which, after some time, received town charters, and through the incorporation of industrialized rural areas into neighboring cities. Thus urbanization in Sweden did not reflect the total movement of the population.

This point is important to remember when interpreting the model. In the model all nonagricultural activiites are characterized as urban. The simulation result will thus yield a higher degree of urbanization compared with real data but this rate will

*The definition of towns in early Swedish statistics is based on administrative rather than functional factors. From 1910 onwards, however, statistics have been available on a more functional definition of towns as "densely populated areas". In that year 34 percent of the population lived in those areas, so the difference between the two concepts is small, at least at the end of the period of study (Historical Statistics of Sweden, 1969).

Table 4. The share of industrial workers occupied in the rural areas by branches, 1896 and 1913.

Branches of industry	1896	1913
Mining and basic metal	99.9	98.7
Metal manufacturing	47.5	37.2
Stone, clay, and glass	85.4	86.2
Lumber, etc.	84.1	81.0
Paper and printing	56.1	60.0
Food products	40.5	40.4
Textile and clothing	36.1	35.9
Leather, rubber, etc.	34.2	23.9
Chemical	43.0	33.6
Power, light, and waterworks	50.0	22.0
All branches	63.3	58.2

Source: Thomas, 1941:179.

better reflect the actual proportion of the population movement than the urbanization figures. Moreover, the model cannot be given a spatial interpretation as has been done in similar studies of Third World countries (see, for example, Kelley and Williamson, 1979:13).

As has already been stressed, Swedish migration was, to a large extent, external and directed toward the United States.* The extent, character, and causes have been investigated in several studies (see, for example, Thomas, 1941; Runblom and Norman, 1976). Econometric studies have been made that deal with factors influencing emigration (Wilkinson, 1967; 1970; Williamson, 1974; Quigley, 1972; Hamberg, 1976). The results strongly support the view that economic factors such as employment opportunities and real income gains were most important factors in the explanation

*Immigration amounted to slightly more than 200,000 during the period of study, but 50 percent originated in the USA, and consisted of emigrants who went back to Sweden after some years in America (Historical Statistics of Sweden, 1969, Part 1: Population:120-125). In this model immigration is not explicitly treated and the migration concept is thus net migration.

of emigration. These studies also deal with the economic situation in Sweden and the USA, i.e., the push/pull factors, which were crucial to emigration. There seems to be no disagreement that the situation in both the sending and the receiving country highly influenced the movement even though the importance that the studies place on the various situations differ. In studies made by historians do push and pull factors explain different waves of emigration? The first wave of emigrants occurred at the end of the 1860s (see Figure 3) mainly as a consequence of the famine during those years. The remaining waves during the 19th century were more closely related to industrial recession and agricultural crises. After the turn of the century emigration seemed to be caused mainly by pull factors in the United States (Carlsson, 1976).

In some migration studies, however, it is the relationships between expected income in the different regions which are considered to be the determining factor in migration. By stressing the comparison of the expected income in various regions and not simply what the economic situation is in one region independent of another, the distinction between push and pull factors becomes artificial. This hypothesis is not only supported by empirical findings (Hamberg, 1976) but also can be justified from the theoretical point of view (Greenwood, 1975; Sjaastad, 1962). The theoretical foundation lies in human capital theory. Migration is looked upon as an investment, and it is the present value (PV) of an investment in migrating from one region to another which determines whether the move was made or not. The present value of migrating from region A to region U can be defined as:

$$PV_{AU} = \sum_{t=1}^{n} \frac{Y_{Ut} - Y_{At}}{(1 + r)t} - \sum_{t=1}^{n} \frac{C_{Ut} - C_{At}}{(1 + r)t}$$

where Y refers to incomes in the different regions, C to the costs associated with residence in the two localities, and r is the rate of discount. Only if PV > 0 will an individual residing in A move to U, and in a choice between different moving possibilities, the one which maximizes PV will be chosen. When applying this model one has to make some very rough approximations.

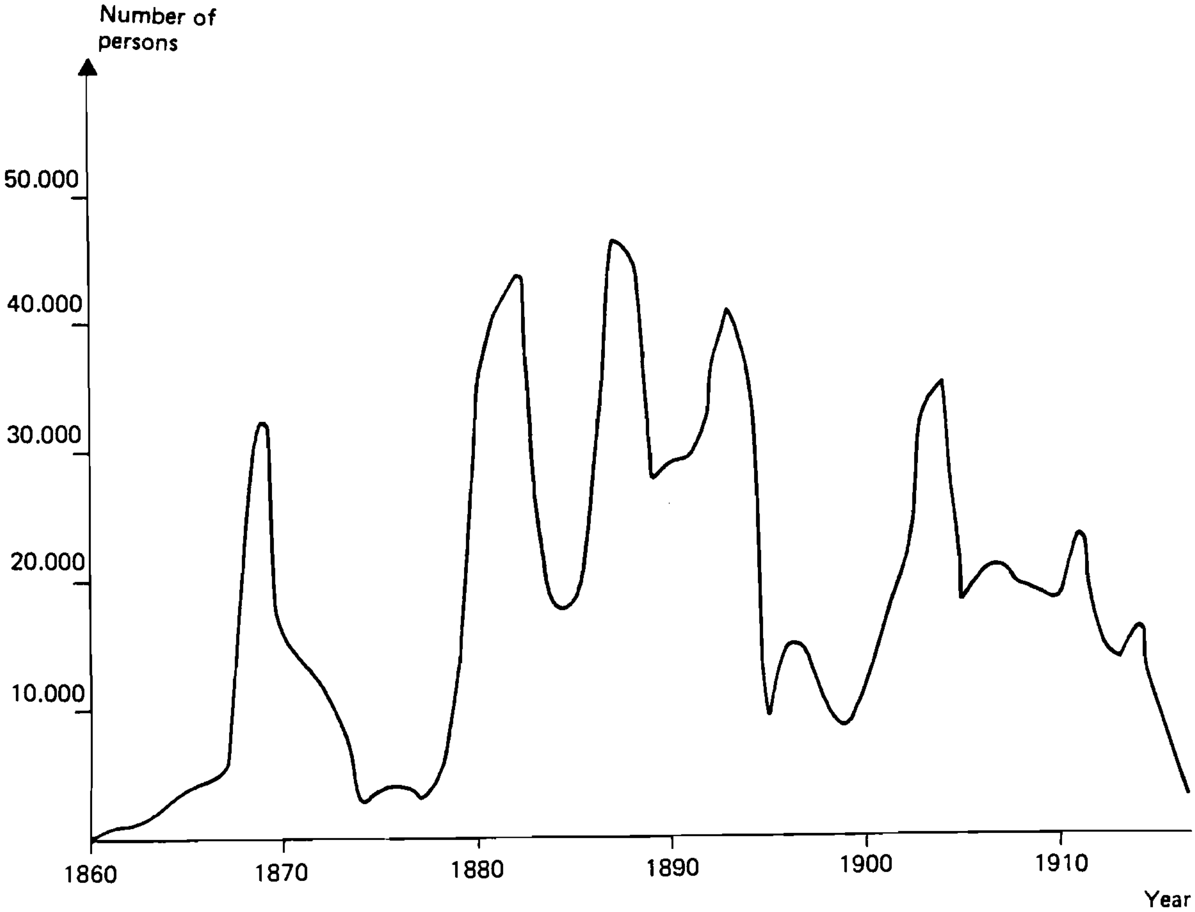

Figure 3. Reigstered Emigration from Sweden to Non-European countries, 1860-1915

Source: Runblom and Norman (1976) Table 5.1, p. 117.

In this model the present value of future earnings is approximated by current wages in different localities. In some migration studies the income variables have been disaggregated into wages and the probability to get a job, approximated by the unemployment rate (Todaro, 1969). But since the model that will be used in the Swedish case study assumes full employment and since the wages derived in the model and used in the migration function are sensitive to the supply conditions of labor, there is no need to explicitly capture this aspect in the formulation. The cost differences between the three possible localities in the model—rural areas, urban areas, and the United States—are captured through a cost of living index specific to the different regions. Of course, the costs of transportation across the Atlantic did play a large role, but it is not clear if the price of the ticket explains the fluctuation in emigration or not, even though the price fell in relation to wages (Semmingsen, 1972:58). On the other hand, the transportation costs do explain the low emigration rate among the poorest social classes, but this effect is captured by parameter values in the migration functions. Thus, in this model, the propensity to emigrate from Sweden to the United States (em) is only a function of the relation between the current real wages in the two countries:

$$em = f\left(\frac{W_{USA}/COL_{USA}}{W_S/COL_S}\right)$$

The migration from rural to urban areas and from Sweden to the United States is determined in two stages in the model. First, the outmigration rate from agriculture is fixed as a function of the relation between a weighted real wage in the immigration regions (the urban areas and the United States) and agriculture:*

*This formulation of the migration functions is rather ad hoc. It would be more consistent with the underlying assumption of rationality in the rest of the model if the functions were derived from utility maximization conditions.

$$m \equiv \frac{M}{N_1} = 1 - e^{-\eta W^*} \tag{43}$$

$$W^* = \left[d \frac{W_u}{COL_u} + (1 - d) \frac{W_{USA}}{COL_{USA}} \right] \Bigg/ \frac{W_1}{COL_1} \tag{44}$$

Second, the emigration rate, em, is treated as a function of the relation between real wages in the urban areas and the United States:

$$em \equiv \frac{E}{M} = 1 - e^{-\theta (W^{**})} \tag{45}$$

$$W^{**} = \left(\frac{W_{USA}}{COL_{USA}} \right) \Bigg/ \frac{W_u}{COL_u} \tag{46}$$

where M is the total amount of net migrants out of the rural areas, E is the amount of net emmigrants moving abroad and η, θ, and d are parameters. The cost of living, COL, in the agriculture and the urban areas are determined endogenously. But the cost of living, COL_{USA}, and the wage level, W_{USA}, in the United States are exogenous variables

$$COL_j = \sum_{i=1}^{5} P_i^D \frac{P_i^D D_{ij}}{C_j} \qquad j = A, U \tag{47}$$

Recall from the labor market discussion that wages in the urban sectors are in a close relationship to each other, therefore, W_u, which is used in equation (14) to capture this relation, can be interpreted as a wage index for the urban sectors.

POPULATION GROWTH

One of the dynamic forces in the model is the growth of the population. The Swedish population experienced great changes during the second part of the 19th and the beginning of the 20th century. With an average growth rate of 0.7 percent per year, the population increased from 4.2 million to slightly more than 5.6 million at the outbreak of World War I. As shown in Figure 4 this was not a smooth increase but a fluctuating one which was due to both changes in birth and death rates as well as to emigration. Fridlizius (1979) pointed out in a study about the demographic transition in Sweden that the 1890s were the dividing time between a period of accelerating population growth, due mainly to decreasing mortality (1810-1890), and the third phase of demographic transition which is characterized by a strong decline in fertility.

The magnitude of the demographic variables are very different between rural and urban areas. In Table 5 the crude birth and death rates, and the resulting increases in population, are displayed for the two types of regions. The urban areas showed a higher rate of both births and deaths during the initial years of industrialization. The great difference in the death rate between urban and rural areas is noticeable, especially when one considers that the proportion of the population in the ages 15-60 was higher in urban areas than in rural areas (Thomas, 1941:29). The decline in crude birth and death rates were, on the other hand, higher in the urban areas causing the relation in ratios between the two types of areas to be reversed at the end of the First World War. The patterns of change were similar even though the magnitudes differed. Decline in mortality and fertility began more or less simultaneously in both rural and urban regions. The demographic dualism between rural and urban areas was thus reflected in the intitial differences in the demographic variables rather than in the patterns of change.

In the model population growth is more or less exogenous. Even though there are evidences of a causality from economic to some demographic variables, for example, fertility (Wilkinson, 1973), it has not been possible at this stage of modeling to endogenize them. Emigration is, on the other hand, endogenous in the model and is responsible for a major part of the changes in population (see Figure 4). Population growth is described by the following two equations, one for the rural, and one for the urban areas:

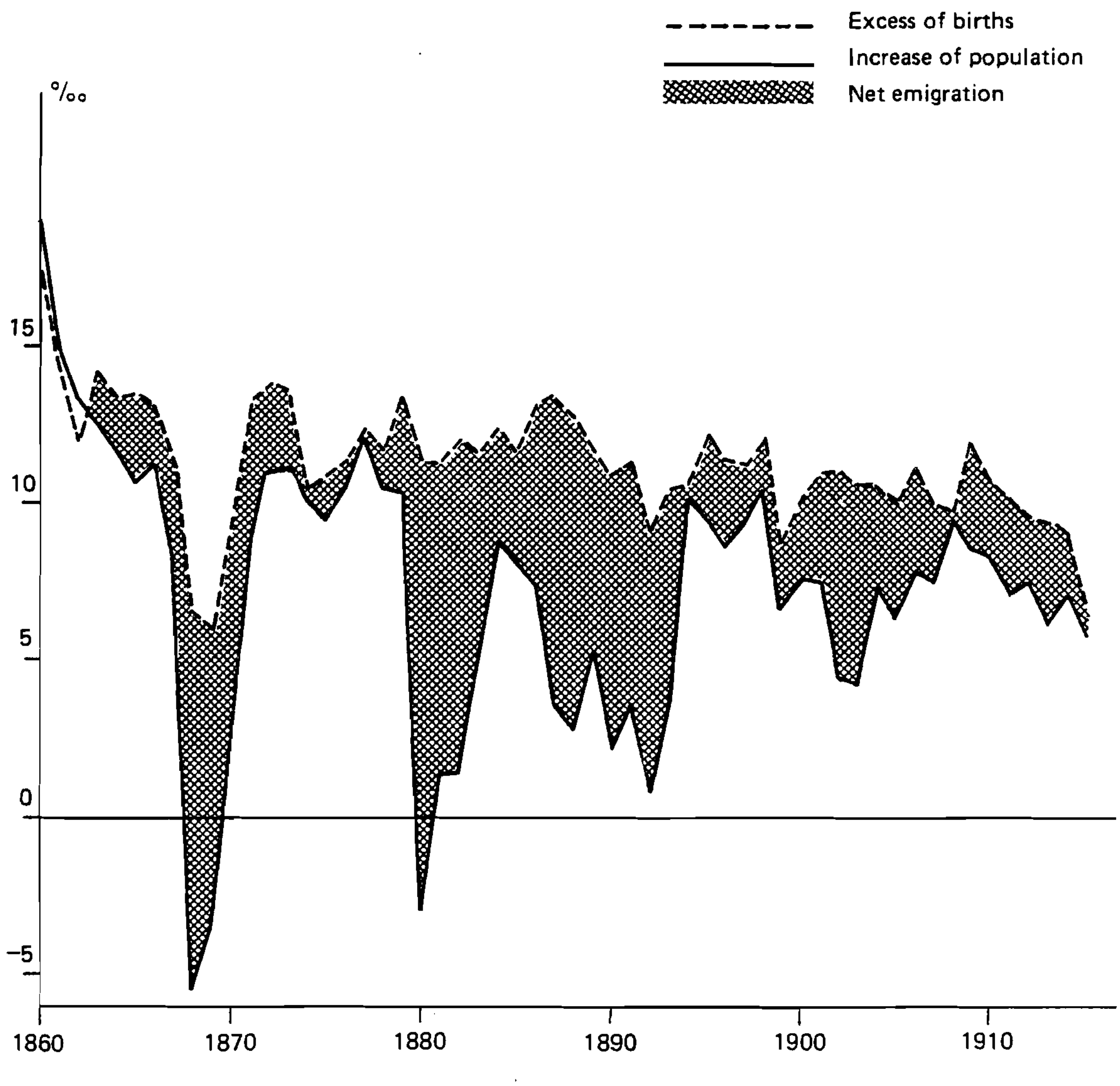

Figure 4. Population changes, 1860-1914.

Source: Historical Statistics of Sweden (1969) Table 28.

Table 5. Changes in births and deaths, 1861-1920.

Period	Crude birth rate			Crude death rate			Natural increase		
	Rural	Urban	Ratio of urban to rural (x 100)	Rural	Urban	Ratio of Urban to rural (x 100)	Rural	Urban	Ratio of urban to rural (x 100)
1861-70	31.2	33.0	106	19.3	26.2	136	11.9	6.8	57.1
1871-80	30.2	32.1	106	17.3	24.1	139	12.9	8.0	62.0
1881-90	28.7	31.1	108	16.4	19.7	120	12.3	11.4	92.7
1890-00	27.2	27.1	100	16.1	17.4	108	11.1	9.7	87.4
1901-10	25.7	25.9	101	14.9	14.9	100	10.8	11.0	101.9
1911-20	22.7	20.5	90	14.6	13.5	92	8.1	7.0	86.4

Source: Thomas (1941) Table 9.

$$N_1(t) = N_1(t-1)(1 + f_1) - M(t-1) \tag{49}$$

$$N_u(t) = N_u(t-1)(1 + f_u) + M(t-1) - E(t-1) \tag{50}$$

The changes in population are thus a consequence of the natural rate of population increase (f) and migration. National rates of population growth differ between regions and over time, and are, therefore, treated as exogenous variables and not as fixed parameters in the model.

This formulation of population growth makes the model useful to analyze the existence of long swings or "Kuznets cycles" in the Swedish prewar development. The Kuznets-cycle hypothesis is concerned with the fluctuations of 15 to 25 years duration in the rate of growth of different variables. A discussion of these cycles can be found, for example, in Kuznets (1958), Abramovitz (1961), and Easterlin (1966). Morris Wilkinson (1967) has found evidence of long swings in the growth of the Swedish population and in some related economic variables. The population increase exhibits long swings and emigration has dominated its amplitude down to the first decade of the 20th century. He also found that the growth of capital formation and manufacturing output shows long waves. Furthermore, swings in manufacturing appear to lead to waves in population growth which is followed by changes in capital formation. He concludes by discussing the sources of the swings in manufacturing:

> It would be very convenient to place the source of the swings in Swedish manufacturing in the growth of the British economy. There is considerable evidence of long swings in significant sectors of the British economy. Furthermore, the turning points of the British long swings are provocatively close to the turning points of the Swedish long swings. Swedish exports do indeed give some support for this line of thinking. Prior to 1900, the growth of Swedish exports exhibits swings which consistently lead the swings in manufacturing (Wilkinson, 1967:38).

In the model, foreign trade is a crucial variable. The formulation makes it possible for long swings in manufacturing output to be initiated through exports, and eventually such swings can, via wage formation, be transmitted to emigration as well as to urbanization, and thus cause waves in population growth.

EXTENSIONS OF THE MODEL

This formulation of the model is the beginning of a study of the development of the prewar period in Sweden using a simulation model. Numerous crucial questions could be analyzed. Some questions, however, would need an extended model in order to be answered. Three of these possibilities will be mentioned briefly.

(1) Investments and capital formation are exogenous in the agricultural and urban sectors. This is because of the difficulties in finding a reasonable allocation mechanism to capture the imperfect capital market. If such an allocation could be modeled it would be possible to analyze how important a growing and more efficient capital market was in the Swedish case.

(2) Demographic variables, with the exception of migration, are exogenous in the model. There is evidence indicating a strong influence of economic factors on demographic variables such as fertility (see, for example, Wilkinson, 1973). An endogenizing of the natural increase of population should cast further light on the interrelationships between demography and the economy.

(3) The role that residential building played in Swedish development has been questioned in studies of the prewar period. Its share of the total investment adds up to one third of the increase in the investment ratio. Construction of dwellings is one very obvious consequence of urbanization and has also been stressed as one of the explanatory variables of the Kuznets cycle (Easterlin, 1966). Therefore, it would be worthwhile to treat the housing sector—the demand for it, and the investment in it—more explicitly in the model, and thus analyze its importance for the Swedish demoeconomic development.

APPENDIX I: MATHEMATICAL STATEMENT OF THE MODEL

PRODUCTION SECTOR SUBSCRIPTS

1. Agriculture, forestry, and fishing
2. Export-oriented industry
3. Homemarket-oriented industry
4. Services
5. Building and construction

HOUSEHOLD SECTOR SUBSCRIPTS

A. Households in the agricultural sector (i.e., production sector, 1)

U. Households in the urban sector (i.e., production sector, 2-5)

ENDOGENOUS VARIABLES

P_i domestic production cost of commodity i = 1,...,5

P_i^D domestic price of commodity i = 1,...,5

P_j^* value-added prices in sector j = 1,...,5

X_j gross output in sector j = 1,...,5

X_{ij} deliveries of intermediate goods from sector i to sector j

H composite of labor and capital input in the agricultural sector

L_j employment in sector j = 1,...,5

L_u employment in urban sectors

W_u index of the level of wages in the urban sectors

W_j wage rate in sector j = 1,...,5

Π_1 rent in the agricultural sector

RC_j rate of return on capital in sector j = 2,...,5

RC_u index of rates of return in the urban sectors

S_A savings in the agricultural sector

S_U savings in the urban sectors

S^P total private savings

Y_j^{Dl} disposable income by workers in sector j = A,U

Y_j^{Dc} disposable income by capitalists in sector j = A,U

D_{ij} consumption of commodity i = 1,...,5 in sector j = A,U

C_j total consumption in sector j = A,U

COL_j cost of living in sector j = A,U

EX_j export of commodity i = 1,...,3

IM_i import of commodity i = 1,...,3

S^G savings by the government

M total amount of net migrants from the rural areas

E total amount of net emigrants

I_j^B investments in buildings and plants in sector j = A,U

I_j^M investments in other capital equipments in sector $j = A,U$

K_j capital stock in sector $j = 2,\ldots,5$

Q_j user cost of capital in sector $j = 2,\ldots,5$

EXOGENOUS VARIABLES

K_j capital stock in sector $j = A,U$

I_1 total gross investment in sector 1

I_u total gross investment in the urban sectors

P_i^W price level expressed in Swedish currency, on international markets on commodity $i = 1,\ldots,3$

h_j labor augmenting technical change in sector $j = 1,\ldots,5$

g_j capital augmenting technical change in sector $j = 1,\ldots,5$

f_1 net natural rate of population increase in the rural areas

f_u net natural rate of population increase in the urban areas

COL_{USA} cost of living in the USA

W_{USA} wage level in the USA

F net capital inflow

C^G consumption by the government

R total land acreage

N_1 total population in the rural areas

N_u total population in the urban areas

RE remittances from emigrants

A technical change in agriculture

p_j labor participation rate in sector $j = A,U$

PARAMETERS

ϕ_i	*ad valorem* custom duty of imports of commodity $i = 1,\ldots,3$
a_{ij}	input of commodity $i = 1,\ldots,5$ per unit of output in sector $j = 1,\ldots,5$
$\alpha, \delta_j, \gamma_j$	distribution parameters in the production function of sector j
ρ_j	substitution parameter in sector $j = 1,\ldots,5$
ω_j	index of the relative wage rate in sector $j = 2,\ldots,5$
β_{ij}	marginal propensity to consume commodity $i = 1,\ldots,5$ by household in sector $j = A,U$
b_{ij}	subsistence consumption of commodity $i = 1,\ldots,5$ in sector $j = A,U$
s^l, s^c	rate of savings out of labor income (l) respectively, capital- and land income (c)
ε_i	price elasticity parameter in the export demand for commodity $i = 1,\ldots,3$
μ_i	price elasticity parameter in the import demand for commodity $i = 1,\ldots,3$
σ_i	annual rate of change of world market trade with commodity $i = 1,\ldots,3$
ψ	annual rate of change in import of commodity 2
τ^l, τ^c	tax rate out of labor income (l) respectively, capital- and land income (c)
κ^B, κ^M	annual rate of depreciation of buildings and plants (B) and other capital equipment (M)
ζ_j	share of buildings and plants in the capital stock of sector $j = 1,\ldots,5$
r	annual rate of growth in land acreage
$\lambda_1^A, \lambda_j^g, \lambda_j^h$	annual rate of technological change in sector $j = 1,\ldots,5$
η, θ	parameters in the migration and emigration functions

d weight in the migration function

q_j index of the relative rates of return in sector $j = 2,\ldots,5$

PRICES

$$P_i^D = \frac{im_i}{1 + im_i}\left(1 + \phi_i\right) P_i^W + \frac{1}{1 + im_i} P_i \qquad i = 1,3 \qquad (1)$$

$$P_2^D = \overline{P}_2^W \qquad (2)$$

$$P_i^D = P_i \qquad i = 4,5 \qquad (3)$$

PRODUCTION AND TECHNOLOGY

$$P_j^* = P_i - \sum_{i=1}^{5} P_i^D a_{ij} \qquad i = j = 1,\ldots,5 \qquad (4)$$

$$X_1 = A\ R^{\alpha}\ H^{1-\alpha} \qquad (5)$$

$$H = \left\{\delta_1\left(g_1\ K_1\right)^{-\rho_1} + \gamma_1\left(h_1\ L_1\right)^{-\rho_1}\right\}^{-\frac{1}{\rho_1}} \qquad (6)$$

$$X_j = \left\{\delta_j\left(g_j\ K_j\right)^{-\rho_j} + \gamma_j\left(h_j\ L_j\right)^{-\rho_j}\right\}^{-\frac{1}{\rho_j}} \qquad j = 2,\ldots,5 \qquad (7)$$

$$X_{ij} = a_{ij}\ X_j \qquad \begin{cases} i = 1,\ldots,5 \\ j = 1,\ldots,5 \end{cases} \qquad (8)$$

$$\frac{W_1 \; L_1}{P_1^* \; X_1} = (1 - \alpha) \; \gamma_1 \left[\frac{H}{h_1 \; L_1}\right]^{\rho_1} \qquad (9)$$

$$\Pi_1 = P_1^* \; X_1 - W_1 \; L_1 \qquad (10)$$

$$Q_i = P_2^D \; (RC_i + \kappa^M)(1 - \zeta_i) + P_2^D \; (RC_i + \kappa^B) \; \zeta_i$$

$$i = 2,\ldots,5 \qquad (10a)$$

$$\frac{W_j \; L_j}{P_j^* \; X_j} = \gamma_j \left[\frac{H}{h_j \; L_j}\right]^{\rho_1} \qquad j = 2,\ldots,5 \qquad (11)$$

$$\frac{Q_j \; K_j}{P_j^* \; X_j} = \delta_j \left[\frac{H}{g_j \; K_j}\right]^{\rho_1} \qquad j = 2,\ldots,5 \qquad (12)$$

$$RC_j = q_j \; RC_u \qquad j = 2,\ldots,5 \qquad (13)$$

$$W_j = \omega_j \; W_u \qquad j = 2,\ldots,5 \qquad (14)$$

FACTOR MARKETS

$$L_1 = p_1 \; N_1 \qquad (15)$$

$$L_u = P_u \; N_u \qquad (16)$$

$$\sum_{j=2}^{5} L_j = L_u \qquad (17)$$

$$\sum_{j=2}^{5} K_j = K_u \qquad (18)$$

HOUSEHOLD DEMAND AND INCOME

$$P_i^D D_{ij} = b_{ij} P_i^D + \beta_{ij} \left(C_j - \sum_{i=1}^{5} b_{ij} P_i^D \right) \tag{19}$$

$i = 1,\dots,5$
$j = A,U$

$$C_j = (1 - s^l) Y_j^{Dl} + (1 - s^c) Y_j^{Dc} \qquad j = A,U \tag{20}$$

$$Y_A^{Dl} = (1 - \tau^l) Y_A^l = (1 - \tau^l) W_1 L_1 + RE \tag{21}$$

$$Y_A^{Dc} = (1 - \tau^c) Y_A^c = (1 - \tau^c) \Pi_1 \tag{22}$$

$$Y_U^{Dl} = (1 - \tau^l) Y_U^l = (1 - \tau^l) \sum_{j=2}^{5} W_j L_j \tag{23}$$

$$Y_U^{Dc} = (1 - \tau^l) Y_U^c = (1 - \tau^c) \sum_{j=2}^{5} Q_j K_j \tag{24}$$

EXPORT AND IMPORT

$$EX_i = EX_i^o \left(\frac{P_i}{P_i^w} \right)^{\varepsilon_i} e^{\sigma_i t} \qquad i = 1,3 \tag{25}$$

$$im_i \equiv \frac{IM_i}{X_i - EX_i} = im_i^o \left(\frac{P_i}{(1 + \phi_i) P_i^W} \right)^{\mu_i} \tag{26}$$

$i = 1,3$

$$im_2 \equiv \frac{IM_2}{X_2 - EX_2} = im_2^o \quad e^{-\psi t} \tag{27}$$

$$P_2 \; EX_2 = P_1^W \; IM_1 + P_2^W \; IM_2 + P_3^W \; IM_3 - P_1 \; EX_1$$

$$- P_3 \; EX_3 - F - RE \tag{28}$$

SAVINGS AND INVESTMENT

$$S_A = s^l \; Y_A^{Dl} + s^c \; Y_A^{Dc} \tag{29}$$

$$S_U = s^l \; Y_U^{Dl} + s^c \; Y_U^{Dc} \tag{30}$$

$$S^P = S_A + S_U \tag{31}$$

$$S^G = \sum_{j=1}^{5} \tau^l \; Y_j^l + \sum_{j=1}^{5} \tau^c \; Y_j^c + \sum_{i=1}^{3} \phi_i \; P_i^W \; IM_i + F - C^G \tag{32}$$

$$I_1^B = \zeta_1 \; I_1 \tag{33}$$

$$I_1^M = (1 - \zeta_1) \; I_1 \tag{34}$$

$$I_u^B = \zeta_u \; I_u \tag{35}$$

$$I_u^M = (1 - \zeta)\ I_u \tag{36}$$

BALANCING EQUATIONS

$$X_1 = \sum_{j=1}^{5} D_{1j} + \sum_{j=1}^{5} a_{1j}\ X_j + EX_1 - IM_1 \tag{37}$$

$$X_2 = \sum_{j=1}^{5} D_{2j} + \sum_{j=1}^{5} a_{2j}\ X_j + P_2^D\ I_u^M + P_2^D\ I_1^M \tag{38}$$

$$X_3 = \sum_{j=1}^{5} D_{3j} + \sum_{j=1}^{5} a_{3j}\ X_j + EX_3 - IM_3 \tag{39}$$

$$X_4 = \sum_{j=1}^{5} D_{4j} + \sum_{j=1}^{5} a_{4j}\ X_j \tag{40}$$

$$X_5 = \sum_{j=1}^{5} D_{5j} + \sum_{j=1}^{5} a_{5j}\ X_j + P_5^D\ I_u^B + P_5^D\ I_1^B \tag{41}$$

$$GDP = X_1 + X_2 + X_3 + X_4 + X_5 - \sum_{i=1}^{5} \sum_{j=1}^{5} X_{ij} \tag{42}$$

MIGRATION

$$m \equiv \frac{M}{N_1} = 1 - e^{-\eta W^*} \tag{43}$$

$$W^* = \left[d \; \frac{W_u}{COL_u} + (1 - d) \; \frac{W_{USA}}{COL_{USA}} \right] \Bigg/ \frac{W_1}{COL_1} \tag{44}$$

$$em \equiv \frac{E}{M} = 1 - e^{-\theta (W^{**})} \tag{45}$$

$$W^{**} = \left(\frac{W_{USA}}{COL_{USA}} \right) \Bigg/ \left(\frac{W_u}{COL_u} \right) \tag{46}$$

$$COL_j = \sum_{i=1}^{5} P_i^D \; \frac{P_i^D \; D_{ij}}{C_j} \qquad j = A, U \tag{47}$$

DYNAMICS

$$K_j = K_j(t-1) + I_j(t-1) - \left[\kappa^B \; \zeta_j + \kappa^M \; (1 - \zeta_j) \right] K_j \tag{48}$$

$$j = A, U$$

$$N_1(t) = N_1(t-1)(1 + f_1) - M(t-1) \tag{49}$$

$$N_u(t) = N_u(t-1)(1 + f_u) + M(t-1) - E(t-1) \tag{50}$$

$$R(t) = R(t-1)\ e^{r} \tag{51}$$

$$A(t) = A(t-1)\ e^{\lambda_1^A} \tag{52}$$

$$g_j(t) = g_j(t-1)\ e^{\lambda_j^g} \qquad j = 1,\ldots,5 \tag{53}$$

$$h_j(t) = h_j(t-1)\ e^{\lambda_j^h} \qquad j = 1,\ldots,5 \tag{54}$$

APPENDIX II: TABLES

Table II.1. Employment in different sectors,1871-1915.

	Agriculture		Manufacture		Transport and communication		Public administration		Total[a] employment	Total population
	1000	Share		Share		Share		Share		
1871/1875	1060,7	0,793	200,5	0,150	27.5	0,021	48,9	0,036	1337,6	4274,0
1976/1880	1079,9	0,775	212,2	0,152	39,9	0,027	61,8	0,044	1393,8	4500,0
1881/1885	1081,0	0,755	236,4	0,166	44,5	0,031	69,2	0,048	1431,1	4604,7
1886/1890	1070,9	0,742	254,7	0,177	43,9	0,030	74,1	0,051	1443,6	4741,7
1891/1895	1060,6	0,712	302,1	0,203	48,9	0,032	78,7	0,053	1490,3	4831,8
1896/1900	1054,3	0,667	390,0	0,247	57,7	0,036	79,3	0,050	1581,3	5032,1
1901/1005	1027,5	0,631	443,1	0,272	70,8	0,043	87,3	0,054	1628,7	5214,3
1906/1910	990,7	0,602	483,5	0,244	85,6	0,052	85,8	0,052	1645,5	5405,9
1911/1915	970,1	0,574	531,6	0,314	94,1	0,056	95,4	0,056	1691,2	5620,4

[a] Building activities, commerce, and domestic services are excluded

Source: Jungenfelt (1966) Table 1:224.

Table II.2. National product by origin: volume values.[a]

	Agriculture	Manufacture	Building & construction	Transport & communication	Personal private services	Public administration	Housing	Total
1871/1875	485	134	121	32	253	176	176	1269
1876/1880	525	151	144	42	297	103	187	1413
1881/1885	560	193	129	55	331	110	196	1547
1886/1890	585	220	130	64	359	113	208	1656
1891/1895	645	317	122	81	408	115	217	1893
1896/1900	681	473	158	114	465	117	230	2242
1901/1905	658	611	184	158	560	118	249	2518
1906/1910	785	823	175	209	682	121	265	3056
1911/1915	848	996	216	256	832	127	282	3557

[a]Millions of Kronor

Source: Kratz and Nilsson, (1975) Table 3.1, 2.3.1.

Table II.3. Gains in productivity caused by employment movement: agriculture and manufacture sectors.

	I[a] Share of employment (A + M)		II[b] Productivity		III Real productivity	IV Percentage change	V Hypothetical productivity[c]	VI Percentage change	VII Employment removal gain
	A	M	A	M	A + M	per year	A + M	per year	(IV-VI)•100 / IV
1871/1875	0,841	0,159	468	668	500	0,904	500	0,865	4,3
1876/1880	0,836	0,164	486	712	523		522		
1881/1885	0,821	0,179	518	816	571	1,230	571	1,097	10,8
1886/1890	0,808	0,192	546	864	607		603		
1891/1895	0,778	0,222	608	1049	706	2,506	706	1,909	23,8
1896/1900	0,730	0,270	646	1213	799		776		
1901/1905	0,699	0,301	640	1379	862	3,602	862	3,146	12,7
1911/1915	0,646	0,357	874	1874	1228		1175		
1871/1875	0,841	0,159	468	668	500	2,272	500	1,831	19,4
1911/1915	0,646	0,354	874	1874	1228		1033		

[a] From Table II.1.
[b] From Table II.2.
[c] The hypothetical productivity is the production per employee assuming that the share of employment between the two sectors is unchanged during the period.

Table II.4. Gains in productivity caused by employment movement between the industries.[a]

	I Real productivity	II Percentage change per year	III Hypothetical productivity	IV Percentage change per year	V Employment removal gain (III-IV) • 100/II
1871/1875	559	1,051	559	0,531	49,5 %
1976/1880	589		574		
1881/1885	642	1,157	642	0,978	15,5 %
1886/1890	680		674		
1891/1895	777	2,428	777	1,764	27,3 %
1896/1900	876		848		
1901/1905	949	3,331	949	2,793	16,2 %
1911/1915	1317		1250		
1871/1875	559	2,166	559	1,658	23.5 %
1911/1915	1317		1079		
1871/1875	559	1,315	559	0,990	24.7 %
1886/1890	680		648		
1891/1895	777	2,673	777	2,034	23.9 %
1911/1915	1317		1167		

[a] Building activities, commerce, and domestic services are excluded.

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