Economic growth and migration during the industrialization of Sweden

A general equilibrium approach

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ECONOMIC GROWTH AND MIGRATION DURING THE INDUSTRIALIZATION OF SWEDEN

A general equilibrium approach

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Stockholm in September, 1985

Urban Karlström

Contents

1. A Summary of the Study

1.1 INTRODUCTION

This study applies the analytical tool of a computable general equilibrium model to a critical phase of Swedish history, the first wave of industrialization. Some of the issues that are addressed have been debated for more than one hundred years. The consequences of emigration for the Swedish development were discussed as early as the 1880s when Wicksell pointed out that emigration would solve the pauperization problem in Swedish agriculture (Wicksell 1882). Since then numerous scholars have analyzed different aspects of Swedish industrialization. Are there any new aspects to be added on the problems of that time?

Yet while the issues discussed in this study are old, the methods are not. The development of new quantitative methods during the last decade has opened a new research field sometimes called New Economic History. The new tools have given us a possibility to get quantitative answers to questions that have so far only been answered analytically. Many of the questions raised need quantitative answers to be of real interest. Furthermore, the issues are sometimes of such a complexity that they require detailed models. Thus, by applying new methods on the old issues we will hopefully gain further insights into the problems of Swedish industrialization.

In this introductory chapter we will summarize our study, chapter by chapter, in Section 1.3. But before that we will place our study in the context of current research.

1.2 NEW ECONOMIC HISTORY AND COMPUTABLE GENERAL EQUILIBRIUM MODELS

One typical feature of the New Economic History is the use of explicit counterfactual analysis. An alternative state of the world is compared with the actual one. Differences between the two are then ascribed to a certain exogenous factor. This study is an example of this type of comparative dynamics. However, it is more general than many other studies because we take a general equilibrium approach. A partial equilibrium model in which some markets are isolated from the interactions will not capture the complete effects of a certain change. Many of the issues in this study cannot be effectively analyzed by a partial equilibrium model. Take the role of emigration as an example. Emigration diminishes the supply of labor, but also effective demand on the commodity markets and thus indirectly the demand for labor. Without the interactions between factor and commodity markets the results might be very misleading.

Partial equilibrium models have been the common approach in New Economic History. However, in recent years a growing number of studies applying computable general equilibrium models (CGEs for brevity) in economic history have been made (James 1984).[1]

One of the first applications of CGE models is the study by Kelley, Williamson and Cheetham (1972) of the dualistic development of Meiji Japan. With a two sector model they reproduced some key variables in the Japanese history. The study of Meiji Japan was extended in a later work, Kelley and Williamson (1974). This study focused on some of the great issues of that time, aggregated growth performance, investment spurts, demographic change and agricultural development.

In his book Late Nineteenth-Century American Development (1974), Williamson addresses many of the major issues of postbellum economic history. The model consists of two regions, three sectors and three factors. By simulating counterfactual histories he analyzes topics such as the causes of the great depression 1870-96, the impact of capital market imperfections, changes in transport costs, terms of trade, productivity, land expansion and immigration, on economic growth, as well as causes of farmers' discontent.

The models used in these three studies are essentially long-term growth models. They deal with the question of development and economic growth. The models are dynamic, i.e., they incorporate a saving-investment mechanism. However, many sources of growth are exogenous.

Many studies have followed the pathbreaking works by Kelley and Williamson. Some problems that have been analyzed using CGE models are the abolition of tariffs in the 1850s U.S. economy (James 1978), and the regional consequences of the British rearmament program in the 1930s (Thomas 1983). Not only multiregional or multisectoral problems are addressed but also multicountry allocation problems. For example, the effects of the Atlantic slave trade on the growth rates of Africa, the American colonies and Britain are studied in a three-sector CGE model, Darity (1982).

Just a few of the historical applications of CGE models are dynamic; most of them address the issues in a static framework. In this respect our study is close to the approach of Williamson (1974). Our model is atemporal in the basic set-up, but by specifying dynamic links between different solutions a time path will be simulated. The aim is, as in the studies by Williamson, to see how closely the model can replicate history.

1.3 A SUMMARY OF THE STUDY

The process of structural change from a traditional agricultural economy to a modern industrial society has often been described in terms of a dual model of development (Lewis 1954). In Chapter 2 the dual model is used as a starting point when discussing the historical development of Sweden and the structure of our model. The conclusion is that there are two reasons why the dual model is inappropriate when analyzing Swedish industrialization.

First, Sweden had already passed the surplus labor stage when industrialization began. Before the industrial breakthrough in the 1870s Sweden went through a period of fundamental structural changes. One emerging result was the establishment of markets to allocate goods, labor and financial resources. The Swedish economy became commercialized. From the 1870s and onwards, the economy was characterized by a growth process that reallocated resources from agriculture to industry. But this process is better described in neoclassical terms than by the dual model.

Second, the Swedish process of development was more complex than is captured by the dual model. Foreign trade played a crucial role for agriculture as well as for the growing industries. The openness of the Swedish economy was important from another point of view. Liberal legislation, improved facilities of transportation and large American demand for labor linked the Swedish labor market to the American, and emigration was huge.

Savings and capital formation were different in Sweden compared to the dual model. There was significant agricultural saving, an important governmental borrowing abroad and investments in industry and agriculture. Capital formation was only one source of growth. Productivity increases were also significant.

To capture adequately some of the mechanisms that have driven Swedish economic growth our model is extended beyond a two-sector analysis. The traditional rural sector remains one unit, agricultural industries. The modern sector is divided into four: export-oriented industry, homemarket-oriented industry, services, and building and construction. The export-oriented sector consists of industries that primarily meet demand from abroad, such as wood, mining and metal, and paper and pulp. The homemarket sector covers the remaining manufacturing industries, mainly consumer goods. The service sector is an aggregate of various kinds of services: commerce, public administration, domestic services and services of dwellings. The building and construction sector accounts for a large share of the investment. These four non-agricultural sectors are treated as the urban sector in the model.

In Chapter 3 the model is discussed equation by equation. The basic structure of the model is in some respects close to the multi-sector growth model developed by Johansen (1974). In every sector output is assumed to be a function of two types of inputs: resources and intermediate goods. In the four urban sectors, capital and labor are the two resources used. They are assumed to be substitutable factors, which are combined in a conventional neoclassical production function. Constant elasticity of substitution (CES) functions have been chosen for each of the urban sectors. In agriculture, land is treated as a factor of production in addition to capital and labor. Capital and labor are combined in a CES function, which is nested in a Cobb-Douglas function. The requirement for intermediate resources is given by fixed input-output coefficients. The production functions also capture the technological factors.

The model assumes that firms maximize profits and that there is perfect competition in all product and factor markets. Therefore, the factors of production are paid in proportion to the value of their marginal products. All resources are assumed to be fully employed.

There are two labor markets in the model, one rural and one urban, tied together through net migration of population. Thus, the model distinguishes between labor force and population. Rural to urban migration is not the only stream of migrants in the model. Emigration to the United States is also endogenous. The growth of total population also becomes endogenous because of endogenous migration and sector specific rates of births and deaths.

Total savings (endogenously determined in the model) make up total gross investment. Investment is allocated between rural and urban areas. Within the urban sector the entire urban capital stock, not just new investments, is assumed to be mobile.

Savings have three sources: private, government and foreign. Private savings are derived from labor and capital incomes in both rural and urban sectors. Income covering the basic needs of the population is subtracted from the base of savings. The savings share is determined outside the model; the savings ratio from capital income is assumed to be higher than from labor income. Government savings remain after expenditures (exogenously determined) have been deducted from government income (determined by taxes). Foreign saving is exogenous.

The model endogenously determines commodity prices and the demand for different commodities. Thus prices are allowed to influence demand and demand to influence prices. The selected form of demand functions is the linear expenditure system (LES). One demand system is specified for the urban and another for the rural area. Foreign demand is also an explicit part of the model. Exports and imports of the three trade participating sectors are endogenously determined.

For each period of time the model is solved so that a static equilibrium is reached. The growth process is a sequence of static equilibria generated mainly by the following variables: (1) capital growth, determined by endogenously generated savings; (2) productivity growth, which is sector- and factor-specific at rates determined outside the model; (3) population growth, with total population endogenous.

The common procedure of implementing a CGE model is followed when the model is calibrated to the base year 1871. The data base is described in Appendix B. Before making dynamic simulations we analyze the comparative static behaviour. Chapter 4 is devoted to that analysis. For expositional purposes the model is reduced from 103 equations to 35 and linearized. All comparative static effects of marginal changes in each exogenous variable are then calculated and analyzed.

However, comparative statics based on this approach cause two problems. First, only very small changes in the exogenous variables are evaluated since the behaviour of the model is only valid locally. In the historical context changes in crucial variables are often discrete rather than marginal. Therefore one should interpret the comparative static results very cautiously in the context of actual historical conditions. Second, even for the case of a very small change in a given variable between two years, the cumulative effects over a longer period of time could be significant. Therefore, the behaviour of the model could be quite different in the short and the long run.

The importance of the non-linearities in the model is illustrated in the last section of Chapter 4. Comparative static experiments using both the non-linear and the linear versions of the model are undertaken. The conclusion is that the magnitudes are quite different in the two versions even when the change in an exogenous variable is limited to 10 percent.

In the remaining part of the study (Chapters 5 and 6) the complete non-linear model is used. The dynamic simulations cover two decades, the 1870s and the 1880s. Is the model able to replicate the historical trends during this period? This question is discussed in Chapter 5.

There are no well-developed and generally accepted criteria in the literature to test CGE models. Because our model is a long-term growth model we cannot expect the model to replicate the historical development year by year. It is not intended to capture fluctuations caused by the business cycle. Our model predicts growth rates of different variables much better than yearly figures. Key quantitative trends are captured by the model. Aggregated production as well as sectoral production is fairly close to the historical figures. The differences can mainly be attributed to the poor predictions of the aggregated rate of saving. The model generates a larger saving and a faster capital formation than is reported in the historical records. The demographic variables, total and regional population, as well as internal and external migration are also close to historical figures. The turning points in these series are replicated in the model.

Although the model still needs to be refined, the simulation results are sufficiently good to warrant the use of the model in historical analysis. In Chapter 6 some important issues in the early industrialization process are discussed by simulating counterfactual histories. Both static and dynamic counterfactual simulations are undertaken.

The international grain market changed during the 1870s and 1880s. Sharp competition and falling transport costs lowered the prices considerably. The price fall has given rise to the opinion that there was a deep crisis in Swedish agriculture in the 1880s. The massive emigration has been viewed as further evidence. This has been the general consensus since the depression in agriculture was discussed in the Swedish parliament in the 1880s. Recently new statistical evidence has questioned this opinion. Among other things real wage in agriculture did not decrease during this period. Which were the fundamental driving forces behind agricultural development? Did the falling world market price on grain really play such a depressive role?

In a sequence of counterfactual simulations these issues are discussed. Factors specific to agriculture such as productivity growth, increase in population and capital, as well as reclamation of land are analyzed, but also the interaction between domestic and international markets. The surprising result is that increased labor productivity in agriculture lowered rural wage because of the price effects on the commodity market. More efficient agriculture, ceteris paribus, thus had a pauperizing effect on rural population and increased urbanization and emigration. However, the demand for agricultural goods increased rapidly when industrialization went on. In this process the agricultural sector was a bottle-neck. There was not enough agricultural production and prices and wages rose. The effects of falling world market prices on grains were not depressive according to model simulations. Export went down and domestic supply increased. The price effects speeded up the process of urbanization. A larger capacity of the urban sectors increased industrialization and GNP per capita became higher.

What were the consequences of the huge emigration for the Swedish development? It is the issue for the second part of the last chapter. In two dynamic counterfactual simulations we analyze the role of emigration. In the first one the model is closed. No emigration is allowed. Looking at the effect on the agricultural sector in isolation emigration was beneficial. The result is different if one includes the interaction between rural and urban sectors in the analysis. Emigration had a negative supply effect on agricultural output and caused a significant rise in the price of agricultural goods. Terms of trade between agriculture and industry were further improved from the point of view of agriculture. Urban income deteriorated and savings and investment diminished. The process of growth slowed down.

In the second counterfactual simulation the productivity of labor in agriculture is changed in addition to the closing of emigration possibilities. Including the complementary effect on productivity, the welfare effects of emigration are ambiguous.

NOTE

1) CGE models have increasingly been applied to areas where interactions between sectors and markets seem to be significant, for example public finance, international economics, and development economics. See Bergman (1984), Dervis, de Melo and Robinson (1982), and Shoven and Whalley (1984) for a discussion of some of these applications.

2. A Historical Survey

2.1 INTRODUCTION

Swedish industrialization began during the second part of the 19th century. Within four decades a backward agricultural country was transformed into an expansive industrial society with one of the highest growth rates at that time. The 1870s are looked upon as the starting decade of the Swedish industrialization because of the industrial breakthrough of the sawmill industry (Jörberg, 1969).

The shift in labor force allocation is one of the most striking facts during the pre-World War I period. The proportion of labor engaged in agriculture decreased from about 80 percent in the 1870s to slightly over 55 percent in the 1910s. The movement of labor from agriculture to industry was neutralized by a rapid population increase. Thus the rural population grew in absolute terms during the first part of the period. This process was accompanied by a decline in the relative contribution of agriculture to national product (Krantz and Nilsson, 1975). Its share of GNP decreased from 40 percent in the 1870s to 25 percent around 1915 and the contribution of manufacturing increased from 9 to 27 percent. Initially this process was slow, but the Swedish economy had nevertheless entered a new stage.

Compared with the main European countries, industrialization began relatively late in Sweden. Nevertheless some specific circumstances made the industrial breakthrough in Sweden one of the fastest. These circumstances should be accounted for in an analysis of Swedish industrialization. The following points summarize the facts.

1. The role of foreign trade was crucial. Swedish raw materials, timber and iron-ore, were demanded by the growing European industries. But Sweden also exported large amounts of agricultural commodities.

2. Parallel with the growth of export-oriented industries was the establishment of homemarket-oriented industries. But the growing domestic demand was also directed towards the service sector. Services represented a large share of both production and employment.

3. Investment was extensive. Infrastructure such as railways were built at the same time as large investments were made in both industry and agriculture. A large share was financed by import of foreign capital.

4. The growing industries were linked together by an important interindustry trade. But the links were also strong to agriculture and thus important in the process of reallocating resources from agriculture to industry.

5. Despite a large natural increase, the population growth rate was low because of emigration. The growing non-agricultural demand for labor thus competed with foreign demand.

The process of structural change from a traditional agricultural economy to a modern industrial society has been a central issue when studying economic development. It has also given rise to the conceptual framework of the dual economy. With Lewis (1954) models of dual economies became important analytical tools when describing and studying economic development. See for example, Fei and Ranis (1964), Jorgensson (1961), Kelley, Williamson-Cheetham (1972) and Dixit (1972).

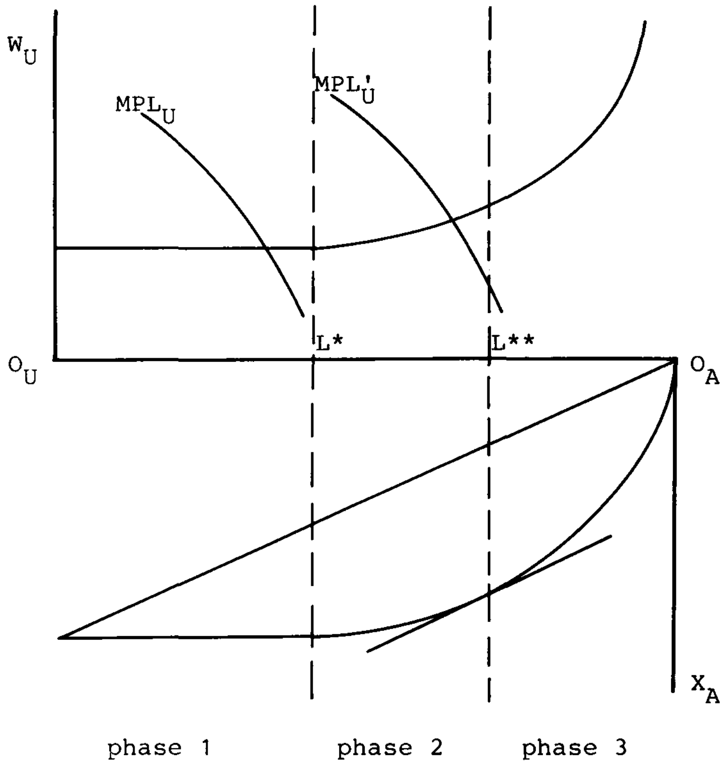
The Swedish process of industrialization was more complex in many respects than is captured by the dual model. Nevertheless, the model provides a natural structure for analysis. Therefore, we will use it as a starting point when discussing the historical development of Sweden. In the next section there is a brief description of the dual model followed by a discussion of the Swedish development (Section 2.3). Relying on historical facts and some hypotheses of Swedish development, we can draw some conclusions about the features of a model of Swedish industrialization (Section 2.4). In the last section, 2.5, we present some issues that will be dealt with in the following chapters.

2.2 THE DUAL MODEL

The basic idea of models of dual economies is that the economy can be divided into two sectors: one "traditional", "backward" or "rural" and one "modern", "advanced" or "urban". Typically, the traditional sector is the same as the agricultural one, while the industrial sector is characterized as the modern sector.

The fundamental structure of these models is illustrated in Figure 2.1 (Dixit, 1972).

Figure 2.1 The dual model of development



The industrial sector (U) is represented in the upper part of the diagram and the agricultural sector (A) in the lower part. Total employment in the economy is measured by the distance O_U - O_A. Wage in the urban sector is denoted by W_U and production in the agricultural sector by X_A. The total production curve in agriculture is drawn in the lower part of the diagram. Beyond a certain point L* it is assumed that the marginal product of labor (MPL) is zero in agriculture. It is also presumed originally that capitalistic principles are not prevalent in the traditional sector. Thus the wage in this phase is not based on the marginal product of labor. Instead, labor is paid its average product. At another point, L**, the marginal product of labor is equal to the institutional wage in agriculture. Before this point is reached rural-to-urban migration will not affect agricultural wage because it is less than the marginal product of labor. However, when agricultural employment is less than O_A - L**, landlords are willing to increase agricultural wage until it is equal to the marginal product of labor. This is the point of commercialization. When this stage is reached, marginalistic principles prevail in both labor markets.

During phase one, reallocation of labor will not affect agricultural output, so that the fixed wage causes the total wage bill to decrease proportionally. If it is assumed that the agricultural surplus is sold to the industrial workers, the urban supply of food increases proportionally to the urban labor force. Reallocation of labor in this phase is thus consistent with constant terms of trade and a constant industrial wage. This is the motivation behind the horizontal part of the supply curve of labor in the upper part of the diagram. When migration moves the traditional sector into phase two, agricultural surplus does not grow proportionally to industrial employment any longer and the relative price of food increases. Thus, the industrial wage has to increase to compensate for higher prices.

The driving force in this model is the process of capital formation. Capitalists are the only savers and profits in the industry are assumed to be reinvested in the industrial sector, thus increasing the marginal product of and demand for labor (shifting MPL_U to MPL'_U). When phase two is reached, the share of profit starts to decline and the process of growth slows down.

This simple two-sector model captures important mechanisms in the process of industrialization. The role of agriculture is to supply surplus labor and to produce a surplus of food.

Capitalists play a crucial role as savers and investors. In the fundamental setup the model implies first an increase and then a decrease in the growth rate. However, technical progress and foreign trade could change the picture. Both could relieve the agricultural bottleneck when the process of industrialization has reached phase two or three. Technical progress in agriculture could increase the productivity of labor and thus the supply of food, and through foreign trade the industrial sector could trade industrial goods in exchange for food without a deterioration of the terms of trade.

The dual model describes some important mechanisms in the process of structural change from an agricultural economy to an industrial society. But, as we will see in the next section, the Swedish development was more complex than what is captured by the dual model.

2.3 THE HISTORICAL TERRAIN

Agriculture

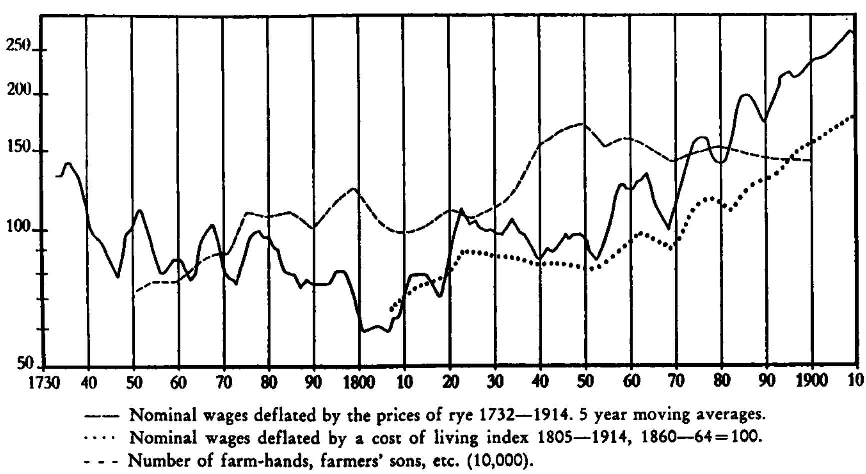
Swedish agriculture went through an important transformation during a period of more than 100 years before the industrial breakthrough of the 1870s. During the 18th century there was a change from what has been described as a feudal system to a freer peasant economy. Owneroccupied farms were only a small proportion of total farms in the early 18th century, but increased considerably over a period ending around the middle of the 19th century (Martinius, 1982).

The division of land holdings toward the end of the 18th century contributed to reduced efficiency of agricultural production. Laws that consolidated strips of land into concentrated holdings were enacted in the middle of the 18th century and early in the 19th century. The process of redistribution and enclosure was slow and took almost 100 years to complete.
At the same time there was a dramatic expansion of cultivated

acreage. During the first 70 years of the 19th century, statistics indicate a three-fold increase in cultivated areas (Thomas, 1941).[1]

Parallel with (or driving) this development was a growth of population. The population almost doubled between 1750 and 1850, from 1.8 to 3.5 million. Roughly 80 percent of the population was dependent on agriculture throughout the period. Therefore almost 1.5 million people were absorbed in the agricultural sector. This had significant social consequences. The process of pauperization was periodically very strong. Figure 2.2 shows the real wage in agriculture for almost 200 years. During the first 80 years there was a decreasing trend, with a very large fall at the end of the 18th century. Despite the faster growth of population in the 1830s and 1840s relative to the end of the 18th century, increasing productivity nearly eliminated wage pressure (Jörberg, 1972b: 334 ff.).

Figure 2.2 Real wages for agricultural workers 1732-1914 and agricultural workers 1871-1900.



1860/64 = 100

Source: Jörberg (1972a).

The increasing trend in the real wage in agriculture that is observed from around 1850 has an interesting interpretation in terms of the dual model. Industrialization began during the second part of the 19th century. The reallocation of labor was thus immediately followed by a considerable increase in rural wage. Therefore, Swedish agriculture could not have been at the surplus labor stage (phase one in Figure 2.1) characterized by an infinitely elastic supply of labor in the urban sector. If that had been the case, real wage in agriculture would not have increased when the demand for industrial labor grew. The evidence thus indicates that the agricultural labor force was efficiently employed at the beginning of the industrialization. Of course, there existed overpopulated farms in Sweden with a zero marginal product of labor. But according to our interpretation of the wage figures these farms were exceptions rather than typical.

During the second half of the 19th century there was an improvement in the terms of trade of agriculture (Jörberg, 1972b: 320 ff.). The dual model predicts a relative price increase for food in the second phase. When total production of food declines because of migration of labor, the relative price of agricultural goods will increase. However, the forces influencing relative prices in the Swedish case were not as clear as in the dual model. The role of foreign trade affected the picture.

Sweden had imported grain for a long period before the beginning of the 19th century. The increased productivity in agriculture decreased imports and eventually generated an export surplus in the 1840s. Sweden exported grain at least until the 1880s. The structural transformation of the agricultural sector was one necessary change to establish Sweden as a grain exporter. The other was the establishment of free trade. During the 1840s, regulations on imports were repealed in England and a new, large market opened up (Fridlizius, 1963). Swedish exports were large. They increased from 400,000 barrels of grain per year around 1840 to 4 million around 1870. In the 1880s the competition from North America and Russia became too strong. The world market prices fell and Swedish exports decreased rapidly.[2]

Foreign demand for Swedish grain thus played an important role both before and during the first phase of industrialization. During the latter part of the 19th century there was an important export of agricultural commodities, despite increasing urbanization. The increase in agricultural foreign demand in interaction with domestic demand determined the relative domestic price of food.

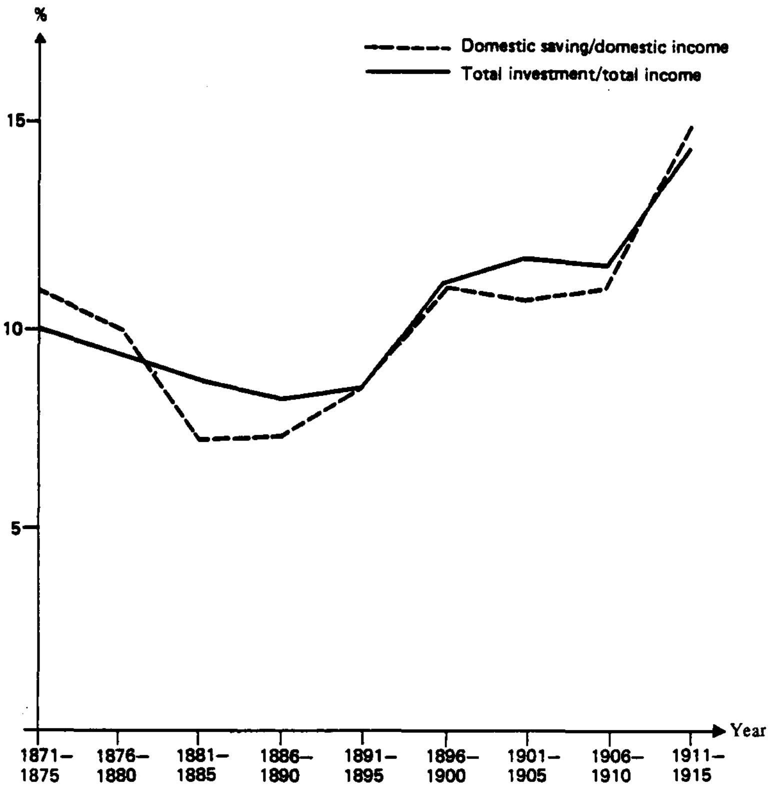
Saving and investment

During the pre-industrial period large investments in agriculture were made in connection with the redistribution and enclosure of land. Thus significant saving must have occurred. There was a widespread system of credits among the peasants during the first part of the 19th century (Bjurling, 1947, and Martinius, 1970). The system was not institutionalized but relied on confidence and mutual financial obligations.

In the middle of the 19th century important institutional changes occurred with the passing of the Bank Reform Act in 1863. Sweden had a very regulated bank system in the period before the reform. The main purpose of the early banks was to supply financial means and subsidize loans to certain favoured industries or firms. Interest rate charges were limited below free market levels. The bank system thus did not manage to absorb savings. The reform changed the situation and among other things ended limitations on interest charges and permitted limited-liability joint-stock banks (Sandberg, 1978, and Nilsson, 1981). After the reform the bank system expanded and was able to compete successfully for private deposits. Compared to other economies at the same level of development, Sweden had a "sophisticated" bank system when industrialization started. But the main suppliers of financial capital to industry (at least to the largest firms) were not the banks. The need was to a great extent met by internal sources through retained profits, and external credit facilities were mainly supplied by private persons with a close connection to the companies (Gårdlund, 1947; Söderlund, 1951; Fridlizius, 1957). Toward the end of the century, private banks became more and more important as depositories for private savings and suppliers of credit.

The domestic pattern of savings during the 1870-1914 period displayed two different tendencies, as can be seen in Figure 2.3. During the 1870s and 1880s the savings rate diminished from almost 11 percent to around seven percent. However, the rate increased rapidly 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 rates (when the investment rate is higher than the savings rate) is net capital borrowing from abroad. It is obvious from Figure 2.3 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). Foreign capital played a crucial role in Sweden's economic development process. Sweden was able to build "cities, railways and factories at the same time" (Gårdlund, 1942:194). Investment in the infrastructure (housing and transportation) made up over 50 percent of investments in building and construction during the prewar period. The housing share fluctuated between 30 and 40 percent and the transportation share was around 20 percent. Industry's share increased from 16 percent in the 1870s to 25 percent before the First World War. Agricultural investment declined from 22 percent to nine percent of total investments during the same period (Lundberg, 1969).

Figure 2.3 Savings and investment rates, 1870-1914.



Source: Adapted from Krantz and Nilsson (1975), Table 2.2.3, pp. 163, 164.

Sweden also differed from the pattern described by the dual model with respect to capital formation. In the model capital is formed by retained profits in the industrial sector. Capitalists are the only savers. Balanced growth requires that investments should be undertaken in agriculture. Such investments are financed by urban capital. Agriculture plays only an indirect role in the process of capital formation. Supply of surplus labor causes profits to go up in the urban sector and investment increases. In Sweden there was considerable agrarian saving before the industrial breakthrough. Thus the agricultural sector was able to modernize without any financial resources from the industrial sector.

In the dual model the rate of savings increases during the surplus labor stage but decreases as industrialization accelerates. Transferring labor to the industrial sector increases wages and labor's share of income during phases two and three. In the Swedish case there was a fall in the rate of savings and investment early during the process of industrialization. The decline is also an indication that Swedish economy had passed the surplus labor stage in the 1870s. Labor's share of industrial income increased between 1870 and 1890 (Jungenfelt, 1966:36). In the 1890s there was a break in the trend followed by a long-term decline. Thus there is a similarity between historical patterns and the predictions of the dual model. The reported decline in the savings' share might be explained by a higher rate of savings out of capital income and a declining capital share of income.

Industry

Before the industrial break-through of the 1870s, the existing industry did not make up any dynamic force in the economy (Heckscher, 1937). For example industrial employment was constant for a very long period of time. But there were quite a few important changes during the first half of the 19th century. Regulations were repealed and freedom of trade and a free foreign trade were established (Myhrman, 1982). The pre-industrial industries were highly regulated, especially the iron industry. Few aspects of the "central planning" of that time were so consistent and uniform as these regulations (Montgomery, 1947, p. 73). The main purpose was to stimulate the export of bar iron through the supply of cheap raw materials. By controlling both prices of charcoal and the establishment of ironworks, the state tried to forestall a presumed exhaustion of the forest. Exports and imports were regulated as well. During the first part of the 19th century all these laws and regulations were gradually repealed.

A rapid growth of the industry came about during the second part of the century (Jörberg, 1961, and Södersten, 1959). The expansion started slowly as early as the 1850s, but the 1870s are considered to be the first phase of industrialization.

In the 1850s the sawmill industry developed due to increased export. Consumer oriented industries were also founded. Many new and mechanized cotton weaving and spinning mills started, as well as tobacco and leather industries and glass works. However, there was no significant rise in industrial employment. The industrial expansion of the 1870s was created mainly by foreign demand. The export industries (wood and iron) grew faster than the consumer-goods industries.

After a period of recession in the 1880s, the industrial share of production and employment increased rapidly in the 1890s (Tables 2.1 and 2.2). During this period industry diversified because of Swedish innovations that gave rise to new and successful companies (Dahmén, 1950). This specialization occurred mainly within manufacturing. It also changed the pattern of export. Export of raw materials declined and was replaced by more refined goods, such as pulp, which took the place of saw timber as an important export good.

> "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 Swedish export statistics. The expansive powers in the exports had thereby been usurped by quite other groups of goods than earlier" (Fridlizius, 1963: 30).

Table 2.1 The number (in thousands) and share of people employed in different sectors in Sweden, 1871-1915.

Period	Agriculture		Manufacture		Transport and communication		Public administration		Total*	Total
	Number	Share	Number	Share	Number	Share	Number	Share	employment	population
1871/1875	1060.7	0.793	200.5	0.150	27.5	0.021	48.9	0.036	1337.6	4274.0
1876/1880	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
1901/1905	1027.5	0.631	443.1	0.272	70.3	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

* Building activities, commerce, and domestic services are excluded.

Source: Jungenfelt (1966), Table 1, p. 224.

Not only foreign demand but also domestic demand was important for industrial development. Domestic demand can be divided into two categories: final demand for consumption or investment and intermediate demand.

The links between different sectors should not be neglected in the process of industrialization. One can expect that industries early in the process have few linkages to other industries in the form of demand and supply of intermediate goods. Every industrial activity relies on or has a possibility for backward or forward linkages to other industries (Hirschman, 1958).[3] These linkages are important in the process of industrialization even though the pattern differs between economies. One can assume that primary activities, such as agriculture, have weak links to the rest of the economy. In the pre-modern phase inputs from other sectors are not needed. Agricultural production is also mainly used for final demand. However, modernization creates a backward linkage through the need of equipments and machines.

Table 2.2 Sectoral value-added: percentage distribution of volume-values.

Year	Agriculture	Manufacturing	Building construction	Transport communication	Personal private services	Public administr.	Housing
1861	39.0	8.3	7.9	1.2	19.3	7.2	17.1
1870	40.1	9.2	6.9	2.1	20.0	7.0	14.7
1880	38.2	9.4	8.9	3.0	21.0	7.0	12.5
1890	35.8	12.7	7.0	4.5	21.4	6.5	12.1
1900	28.2	22.5	7.6	5.5	21.2	4.9	10.1
1910	25.6	27.4	5.0	7.3	22.5	3.8	8.4

Source: Krantz and Nilsson (1975), Table 3.2.2, p. 175.

In the Swedish case linkages between different sectors were created relatively early, and increased as industrialization continued. Input-output coefficients reflect these linkages. Table 2.3 displays the coefficients between agriculture and various other sectors of the Swedish economy.

Table 2.3 Input-output coefficients (a_{ij}) between some sectors of the Swedish economy 1871-1910.[1)]

From sector i to sector j (a_{ij})[2)]	1871	1880	1890	1900	1910
a_{12}	0.2733	0.2922	0.2275	0.1619	0.0868
a_{13}	0.3723	0.3238	0.3553	0.2185	0.1050
a_{21}	0.0017	0.0014	0.0057	0.0070	0.0133
a_{31}	0.0183	0.0262	0.0350	0.0553	0.0659
a_{51}	0.0083	0.0126	0.0136	0.0185	0.0164

1) Sources: App. B, Tables 1, 3, 5 and 17.

2) The definition of sectors, see p. 36.

The demand for intermediate inputs from export-oriented industries (sector 2) to agriculture (sector 1) per unit of output increased almost 8 times between 1871 and 1910. The corresponding increase for homemarket-oriented industries (sector 3) was almost 300 percent. During the same period, agricultural output grew by 96 percent. Thus the backward linkages from agriculture were an important growth creating factor in the process of Swedish industrialization.

Agriculture also gave rise to an important foreward linkage in the Swedish case through deliveries to the food industry and the saw-mill industry. Forestry was an integral part of the agricultural sector particularly in the early part of the period. A large part of the forest was owned by the peasantry. Farmers were occupied with forestry during the winter season. The export-led growth of the saw mill industry thus created an early linkage to agriculture. The input-output coefficients of deliveries of intermediate goods from agriculture to the manufacturing industries were very high in the 1870s (a_{12} = 0.2733 and a_{13} = 0.3723). During the phase of industrialization the coefficients decreased, reflecting the diversification of manufacturing industry.

The proximity of the wood industry to agriculture (especially in the south of Sweden) reinforced the linkage between the sectors. This proximity also facilitated movement of agricultural workers from forestry to jobs in the sawmills.

Growth of capital, increased urban supply of labor, and technical progress made the industrial sector able to respond to increasing demand. The relative contribution of these three factors to industrial growth has been estimated for the period 1870-1913. Labor and capital contributed together to roughly 60 percent and what is called the technical coefficient to about 40 percent (Åberg, 1969:38).

The two-sector dual model does not capture the driving forces of industrialization in the Swedish case. Foreign trade, backward and foreward linkages between different industrial sectors, and technical progress are missing.

The demographic transition

Swedish population growth began to accelerate early in the 19th century. The period of very fast natural increase continued until the end of the century. The 1890s were the dividing years between a period of accelerating population growth caused by decreasing mortality (1810-1890) and the third phase of demographic transition characterized by a strong decline in fertility (Fridlizius, 1979; Hofsten and Lundström, 1976). During the second part of the 19th century Swedish population experienced great changes. With an average growth rate of

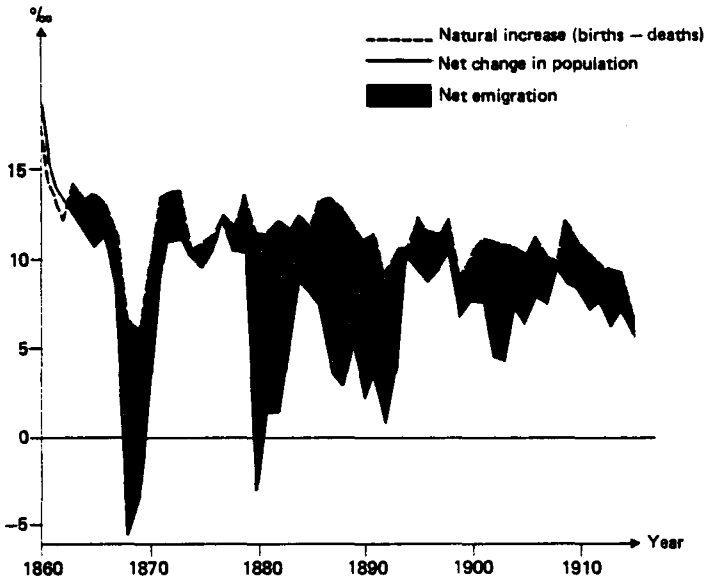
0.7 percent per year, the population increased to slightly more than 5.6 million by about 1915. As shown in Figure 2.4, this was not a smooth increase but a fluctuating one caused by changes in birth and death rates and by emigration.

The magnitudes of the demographic variables are very different between rural and urban areas. In Table 2.4 the crude birth and death rates, and the resulting increase in population are displayed for the two types of regions. The urban areas showed higher rates for both births and deaths during the initial years of industrialization. The great difference between urban and rural death rates is especially notable when one considers that the proportion of the population aged 15-60 was higher in urban areas than in rural areas (Thomas, 1941:29). On the other hand, the decline in crude birth and death rates was higher in urban areas, causing the relative rates in the two types of areas to be reversed by the end of World War I. The patterns of change were similar even though the magnitudes differed. A 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 initial differences in the demographic variables rather than in the patterns of change.[4]

Migration

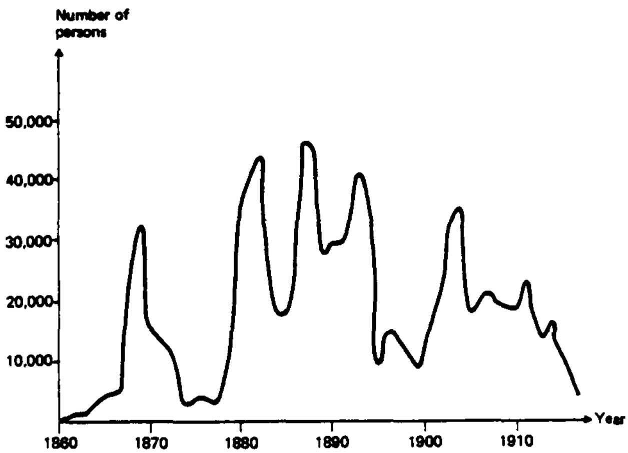
Differences in economic forces between rural and urban areas caused a reallocation of the most mobile production factor: the labor force. Migration was stimulated by industrialization and a strong relationship can be seen between the increase in migration and the industrial breakthrough. Swedish migration 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 10 percent, a figure that had remained constant for decades (Öhngren, 1977, p. 265). But at the end of the 1840s the urbanization rate began to

Figure 2.4 Changes in the population of Sweden, 1860-1914.



Source: Adapted from Historical Statistics of Sweden (1969), Table 28, pp. 95-97.

Figure 2.5 Registered emigration from Sweden to non-European countries, 1860-1915.



Source: Adapted from Carlsson (1976), Table 5.1, p. 117.

Table 2.4 Changes in crude birth and death rates in Sweden, 1861-1920.

	Crude birth rates			Crude death rates			Natural increase rates		
Period	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)
1861–1870	31.2	33.0	106	19.3	26.2	136	11.9	6.8	57.1
1871–1880	30.2	32.1	106	17.3	24.1	139	12.9	8.0	62.0
1881–1890	28.7	31.1	108	16.4	19.7	120	12.3	11.4	92.7
1891–1900	27.2	27.1	100	16.1	17.4	108	11.1	9.7	87.4
1901–1910	25.7	25.9	101	14.9	14.9	100	10.8	11.0	101.9
1911–1920	22.7	20.5	90	14.6	13.5	92	8.1	7.0	86.4

Source: Thomas (1941), Table 9, pp. 44, 45.

Table 2.5 The share (in percent) of industrial workers occupied in the rural areas of Sweden by branches of industry, 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).

increase. Even so, as late as 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 of the total population.[5]

However, at this point it is necessary to notice one specific feature of Swedish industrialization. Industry, to a great extent, was located in rural areas and not in towns and cities (Population Movements and Industrialization, 1941). In particular, industries that initiated the new era, the wood, mining, and metal industries, can be characterized as rural based. Table 2.5 displays the percentage of industrial workers in rural industries in 1896 and in 1913. In 1896 about 63 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. After some time these settlements either received town charters or were incorporated into neighboring cities. Thus urbanization in Sweden did not reflect the total movement of the population.

As was seen in Figure 2.4, population growth during the second part of the 19th century was heavily influenced by emigration. Between 1870 and 1914 the Swedish population increased by 1.4 million people. During the same period, emigration drained the population of roughly 1.1 million people (net).[6] Swedish emigration flowed largely toward the United States. The time profile of emigration can be seen in Figure 2.5. The extent, character and causes have been investigated in several studies (for example Thomas, 1941; Runblom and Norman, 1976). Econometric studies have analyzed the determinants of emigration (Wilkinson, 1967 and 1970; Quigley, 1972; Williamson, 1974; and Hamberg, 1976). The results strongly support the view that economic factors such as employment opportunities and real income gains were most important in explaning emigration. These studies also raise the question of push and pull. There seems to be no disagreement that the situation in both the sending and the receiving country influenced emigration even though the relative importance of each factor in various studies differs.

2.4 SOME CONCLUSIONS

Looking at the period preceding the industrial breakthrough in Sweden we noticed that it was characterized by a rapid increase in population, a deep change in the structure of agriculture and fundamental institutional changes. One emerging result of this phase was the establishment of markets to allocate goods, labor and financial resources. The Swedish economy became commercialized. From the 1870s and onwards, the economy was characterized by a growth process that reallocated resources from agriculture to industry. An important mechanism was changing relative prices among different sectors. Sweden was very open to the world market both on the commodity and factor side. International prices therefore influenced the domestic price system. The Swedish economy around 1870 was not at a surplus labor stage as described by the first phase of the dual model. Instead one of our hypotheses is that the growth process can be described in neoclassical terms.

It is against this general background that our choice of approach should be seen. Our hypothesis is that a computable general equilibrium model will capture the fundamental mechanisms of urbanization and industrialization in the Swedish case. The important interactions between different markets are highlighted in such a model. The analysis of migration also requires taking into account the existence of causality in both directions between economic and demographic variables. When one considers how important such economic variables as 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, it is evident that a general equilibrium approach is most suitable for the problem. Only within such a framework can the complicated relations between the various demographic and economic variables be satisfactorily analyzed (Rogers, 1977).

As we have seen, the two-sector dual model is not detailed enough to describe late 19th century development. It is too aggregate and several important mechanisms that propelled Swedish growth are missing. Our model of Swedish industrialization has to include the following elements:

1. The sector division has to be extended beyond the agricultural/industrial dichotomy. In our model the modern sector is subdivided into four different sectors. Three of them derive from the industrial sector and the fourth is the service sector. Table 2.6 displays the sectors of the model and their empirical counterparts. The manufacturing sector is divided into two parts: export-oriented industries and homemarket-oriented industries. Table 2.7 shows exports and imports in relation to gross production for the various sectors and for the economy as a whole. The role of foreign trade has influenced this division. The strategic role of building and construction motivated treating it as a separate sector. Construction of the railway system as well as housing accounted for a large share of its production. Railway construction was determined by the government to a large extent. Swings in emigration and urbanization had substantial effects on building activities and made the sector quite "population sensitive" (Wilkinson, 1967). Beside the industrial sectors, the urban sector consisted of a service sector. Services grew parallel with industry and increased its share of the labor force substantially. The mechanisms behind its growth were different compared to the other urban sectors. The public sector is a substantial

part of the service sector. There exists no generally accepted theory of the growth of government. However many studies emphasize its interaction with the political process. We have chosen to treat government demand as an exogenous variable in this study. It also seems reasonable to assume a higher income elasticity of private demand for services than for other goods. Therefore, we have chosen to treat service as a separate sector in the model.

Table 2.6 The production sectors in the model and their empirical counterparts.

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

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

Table 2.7 The shares and ratios of exports (EX) and imports (IM) by sector and period in Sweden.

Sector number	Sector	Export share (EX_i/EX)			Export ratio (EX_i/gross output[a])			Import share (IM_i/IM)			Import ratio (IM_i/gross output[a])		
		1871–1875	1891–1895	1911–1915	1871–1875	1891–1895	1911–1915	1871–1875	1891–1895	1911–1915	1871–1875	1891–1895	1911–1915
1	Agriculture, forestry, and fishing	22	10	4	8	4	3	27	27	28	9	12	16
2	Mining and 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
3	Food products	4	16	10	6	17	13	26	15	12	35	17	13
	Textiles and clothing	1	2	1	4	8	6	20	18	10	86	72	33
	Leather, hair and 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-works, and gasworks	–	–	–	–	–	–	–	–	–	–	–	–
	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 and communication	14	14	15	58	43	41	–	–	–	–	–	–
	Services of dwellings	–	–	–	–	–	–	–	–	–	–	–	–
5	Building and construction	–	–	–	–	–	–	–	–	–	–	–	–
	Total	100	100	100	19[b]	22[b]	24[b]	100	100	100	19[b]	22[b]	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: Adapted from Johansson (1967).

2. As we have seen, foreign trade played an important role for agriculture as well as for growing industries. Therefore, we have chosen explicitly to model import and export of agricultural goods as well as some industrial goods.

3. Savings and capital formation were different in Sweden compared to the dual model. There was significant agricultural saving, an important governmental borrowing abroad and investments both in industry and agriculture. All these aspects are built into the model. It is assumed that both labor and capitalists save but with different rates. Savings are partly reinvested directly and partly allocated via the financial market. Foreign borrowing was mainly undertaken by the government and is thus treated exogenously in the model.

4. Consumption demand and its pattern has long been suppressed in explaning long run economic growth. It is clear from different studies that there was a shift in consumption patterns during our period of study. In a study of the cost of living in Sweden during industrialization, Myrdal composed two typical household budgets, one for the middle and one for the end of the 19th century (Myrdal 1933:116 and 138). He found that consumption patterns changed considerably during this time. For example, the share of family income spent on food decreased from 65 to 55 percent. A study by Allen (1955:91), comparing household budgets for industrial and agricultural workers for the year 1913/14, draws the same conclusion. The Engel-effect has been a typical feature of the process of growth in various types of countries at different levels of development (Houthakker, 1957). Sweden was no exception (Parks, 1969). Beside these demand-structure characteristics, duality in the demand pattern is sometimes stressed (Kelley, Williamson, and Cheetham, 1972). The consumers in urban areas display a different consumption pattern from the population in the traditional sector, even for given incomes and prices. Thus urbanization also plays an important, indirect role in the development process through its influence on the pattern of final demand. Against this background, household demand in the model is captured by two expenditure systems, one for the urban region and one for the agricultural region.

5. Backward and forward linkages in the demand for intermediate goods played a great role in industrialization. These links between different sectors can not be neglected and have also been modelled.

6. The model includes three factors of production: labor, capital, and land. Land is only relevant in agriculture because of its independent role in the growth of agricultural production. During the period of study, cultivated acreage increased by 12-15 percent (Holgersson, 1974).

7. Growth of capital, labor and land is not enough to explain production growth. A large residual remains. It is thus necessary to include technical progress which increased the efficiency of capital and labor in the analysis. The technical variables are exogenous in the model.

8. In our historical survey we found that the real wage in agriculture increased during the phase of industrialization. Nevertheless the wage was lower in agriculture compared to the urban wages at the end of the period of study (Bagge, Lundberg and Svennilson, 1933). Thus it is not reasonable to assume an instantaneous allocation in each period in such a way as to equalize wages between rural and urban areas. There was an obvious inertia in the process of adjustment. This is built into the model through the specification of a function for rural to urban migration. In each period of time a certain amount of people migrate due to income differentials and this amount might or might not be enough to equilibrate wages between rural or urban areas. However within each region wages are established to equilibrate supply and demand. Thus there are two labor markets in the model connected by migration.

9. As we have seen, rural to urban migration was not the only possibility. Liberal legislation, improved facilities of transportation and a large American demand for labor created real possibilities for emigration. Thus emigration needs to be incorporated in a model of Swedish industrialization. Emigration in the model is determined by economic factors in Sweden (endogenous in the model) and the U.S. (exogenous).

10. The demographic transition has a strong connection with economic development. But we have not been able to make fertility and mortality endogenous. The rate of natural increase is thus exogenous. In order to capture the dualism of demographic patterns and the influence of urbanization on fertility, these rates are specific to each of the two regions in the model.

2.5 SOME IMPORTANT ISSUES

Swedish industrialization has often been described as a good example of export-driven growth. (See for example Jörberg, 1961.) The contribution of foreign trade to the growth of GNP has been estimated at about 50 percent (the period 1870-1890) (Ohlsson, 1969). Later research has questioned this one-sided picture of Swedish industrialization and emphasized the importance of the growth of the domestic market and the consumer goods industry (Schön, 1982). What role did export really play?

The international grain market changed during the 1870s and 1880s. Sharp competition and falling transport costs lowered prices considerably. The price fall has given rise to the opinion that the 1880s and 1890s were a period of deep crisis in Swedish agriculture. The massive emigration has been viewed as further evidence. This has been the general consensus since the depression in agriculture was discussed in the Swedish parliament in the 1880s. Recent scholars have also shared the view (see for example Svensson, 1965, and Carlsson, 1980). Recently new statistical evidence has questioned this opinion (Jörberg, 1972b: 308 ff.). Among other things, real income in agriculture did not decrease during this period. Which were the fundamental driving forces behind the development of the 1870s and 1880s? Did the falling world market price on grain really play such a depressive role, or were there other offsetting forces?

The proportion of population living in towns and cities increased from 13 to 31 percent between 1870 and 1914. This reallocation of the labor force from the low-productivity agricultural sector to the modern industrial sector with higher productivity contributed positively to economic growth. These gains from labor force reallocation have been estimated with a partial-equilibrium approach (Karlström, 1980: App. 1). The gains differ among decades, but over the whole period nearly 24 percent of the increase in total labor productivity was attributable to urbanization. These figures indicate the potential magnitude of migration. How important was urbanization for the process of growth when taking account of all indirect effects?

The consequences of emigration have been discussed (Wicksell, 1882; Henricsson, 1969) since the 1880s when Wicksell pointed out that emigration would solve the pauperization problem in Swedish agriculture. The rapid increase in population during the first half of the century had been absorbed in agriculture as a result of its transformation. These possibilities were exhausted during the second part of the century. According to this point of view, the North American demand for labor absorbed Swedish surplus labor and relieved potential social problems. But did emigration serve this function? During the late 19th century the Swedish economy entered a new era. Foreign demand, capital formation and technical progress created a completely new situation, not only for agriculture but for the entire economy. A growing domestic urban demand for labor was one consequence. Did the rapidly increasing wage in agriculture indicate that a larger labor force would have relieved a restriction and thus increased growth? To what extent was emigration a substitute for urbanization? What role did emigration really play in the development of Sweden?

NOTES

1) Between 1830 and 1870 Martinius (1970) has found an increase in the productivity of labour by 0.7 per cent annually. The explanation seems to be the redistribution of land and the enlargement of cultivated acreage rather than new methods, equipment and machines (Martinius, 1982).

2) Railway freight costs between Chicago and New York fell by 60 per cent between the 1870s and 1890s and the same fall was also recorded for shipping costs between New York and Liverpool during the same period. The price of American wheat, cif. Liverpool, fell by 45 per cent (Jörberg, 1972b:308-309).

3) An industrial activity can consist of only the final stage, the assembling of different imported components. In such an economy there exists a potential for backward linkages. If demand is large enough, backward integration could create new industries.

4) T.P. Schultz (1984) has estimated that the decline in fertility can be associated with a rise in the female-to-male wage ratio, a reduction in child mortality and urbanization.

5) The definition of towns in early Swedish statistics is based on administrative rather than functional factors. From 1910 onwards, however, statistics have been available for the more functional definition of towns: "densely populated areas". In that year 34 per cent of the population lived in such 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).

6) Immigration amounted to slightly more than 200,000 people during the period of study, but 50 per cent of them originated in the U.S. and consisted of emigrants who returned to Sweden after some years in America (Historical Statistics of Sweden, 1969, Part 1: Population, pp. 120--125). In this study immigration is not explicitly treated and the migration concept is thus net migration.

3. The Model

3.1 INTRODUCTION

Our hypotheses of the Swedish pre-war development were presented and discussed in the previous chapter. We also presented the structure of the simulation model. In this chapter the particular form of the equations will be specified. The arguments for choosing one specification instead of another involve both facts about the Swedish economy and arguments deriving from the theoretical structure of our CGE model.

In the next section the sector classification is presented. Section 3.3 is the main part of the chapter and there the static model is discussed, equation by equation. In Section 3.4 we discuss the savings-investment equality in our static model. A dynamic version of the model has to be formulated to simulate a time path. This model is presented in Section 3.5. In the last section the numerical implementation and the base solution of the static model are discussed.

3.2 SECTOR CLASSIFICATION

As discussed in Chapter 2, the model is divided into 5 production sectors. One homogeneous commodity is produced in each of them. Sectors and commodities are therefore used interchangeably. The 5 sectors and commodities are numbered as follows:

1. Agriculture
2. Export-oriented industry
3. Homemarket-oriented industry
4. Service
5. Building and construction

Sectors 2-5 are treated as a single urban sector (U) in contrast to the agricultural sector (A) when emphasizing the dual aspect of the model. Variables specific to agriculture are thus sometimes labelled with (A) and sometimes with 1.[1]

3.3 EQUATION SYSTEM OF THE STATIC MODEL

Production functions

We have previously discussed and identified the relevant factors of production. In this section we will discuss the specific form of the production functions. However, to make a model which easily can be calibrated we restrict the possible functional forms to Cobb-Douglas functions and CES-functions.

Three factors of production are used in agriculture: labor (L_1), capital (K_1) and land (R_1). If we combine capital, land and labor in a Cobb-Douglas function, we implicitly assume unitary elasticity of substitution between different pairs of factors of production. Moreover, a Cobb-Douglas production function also limits the possibilities for specifying technological change. For example a Cobb-Douglas specification does not allow biased factor-augmenting technical progress. Technical change is always neutral in this case. More flexibility can be introduced by using a CES function and by combining the different factors in two levels.

There are some empirical results on the production relation in agriculture. Jungenfelt (1966) showed that labor's share of value added in agriculture decreased during the pre-World War I period. The share changed from 84 percent in the 1870's to 75 percent between 1910 and 1914 (see Table 3.1). Jungenfelt (1966) is also apparently the only source for estimates of the elasticity of substitution between capital and labor for the pre-war period. The elasticity of substitution was estimated to significantly lower than unity (0.6). A Cobb-Douglas specification for capital and labor therefore appears to be inappropriate. We have chosen to combine capital and labor in a CES production function and then combine the composite output (H_1) with land in a Cobb-Douglas relationship. This nested form of agricultural production function implies that land and capital are functionally separable from land. This means that growth in the amount of cultivated land results in a proportional increase in the marginal productivity of labor and capital. Production is subject to constant returns to scale. We thus assume, for example, that additional land is of the average quality.

The production function in agriculture is thus

$$X_1 = A_1 R_1^{\alpha} H_1^{1-\alpha} \qquad (1)$$

where

$$H_1 = \left\{ \delta_1 (g_1 K_1)^{-\rho_1} + \gamma_1 (h_1 L_1)^{-\rho_1} \right\}^{-1/\rho_1} \qquad (2)$$

We also assume labor saving technical growth. This is built into the model by allowing for factor augmenting technical progress (g_1 and h_1). Note that the factor allocation mechanisms in the model make agricultural output completely predetermined in the static model. There are two factor markets in the model, one rural and one urban, but there is no interplay between them in the static model. Thus the supply of rural and urban factors of production is fixed. Four of the sectors of production are urban-based. The urban supply of capital and labor is endogenously allocated between these four sectors. The separation of the rural and urban factor markets is relaxed in the dynamic model. Factors are reallocated according to differences in marginal factor returns.

Capital and labor are the only factors of production in the four urban sectors. As shown in Table 3.1, neither transport nor industry indicate constant labor shares. Although the sectors in the present model differ from those of Jungenfelt in Table 3.1, sectors 2 and 3 - the export-oriented and the homemarket--oriented industries - compose Jungenfelt's industry sector, and his transport sector constitutes an increasing proportion (6 percent in 1871-1875 and 17 percent in 1911-1915) of sector 4 - the service sector. The elasticities of substitution in industry and transport are estimated at 0.6 (Jungenfelt, 1966, p. 202). Also in the urban sectors we assume labor saving technical growth.

Table 3.1. Labor's share of value added in the Swedish economy, 1870-1914

Period	The whole economy	Agriculture	Industry	Transport
1870-1879	72	84	67	41
1880-1889	72	82	75	46
1890-1899	70	83	71	43
1900-1909	66	80	63	45
1910-1914	64	75	60	47

Source: Jungenfelt (1966), p. 42.

A CES-specification of the production relationship in the urban sectors seems therefore appropriate. In sectors 2-5 the production functions are of the form:

$$X_j = A_j\left\{\delta_j(g_jK_j)^{-\rho_j} + \gamma_j(h_jL_j)^{-\rho_j}\right\}^{-1/\rho_j} \qquad (3\text{-}6)$$

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

where X_j is gross output, K_j sectoral capital stock, and L_j sectoral employment. The technical coefficients are denoted by g_j and h_j respectively. The use of intermediate products is assumed to be a constant fraction of sectoral output, reflected in the scale parameter A_j:

$$A_j = \frac{1}{1 - \sum_i a_{ij}} \;.$$

The input-output coefficients are denoted by a_{ij}. Deliveries of intermediate goods from sector i to sector j are thus X_{ij},

$$X_{ij} = a_{ij}X_j \qquad i = 1,\ldots,5 \;;\; j = 1,\ldots,5 \qquad (7\text{-}31)$$

This formulation allows for different values of the parameters g_j, h_j, A_j, δ_j, γ_j and ρ_j in the different sectors. The substitution parameter is ρ_j, defined as

$$\rho_j = \frac{1}{es_j} - 1$$

where es_j is the sectoral elasticity of substitution.

The supply of total labor and total capital in the urban sector is predetermined in the static model by historical development. However within the urban region labor and capital are allocated among the four sectors according to profit maximization criteria. Thus our modelling of the capital stock differs among sectors.

Capital is of the "putty-clay" type with respect to region. Once installed, it cannot be reallocated to another region. As previously indicated only new investments will be allocated between the two regions. Capital is treated as of a "putty-putty" type with respect to urban sectors. In every period or solution of the model, the entire urban capital stock, not just new investments, is assumed to be completely mobile. This treatment of rural and urban capital seems acceptable from an empirical point of view. In a primarily rural-agrarian society with simple industrial capital, it does not seem too unreasonable to assume that it was easier to switch capital from one industrial use to another than from agricultural use to industrial. Another reason for assuming "putty-putty" capital within the urban region is that it is difficult to formulate reasonable investment functions for allocating new investments among the urban sectors, especially considering the complete lack of data on sectoral rate of return on capital.

The allocation of labor is parallel to the allocation of capital. We are mainly interested in migration between rural and urban regions. Therefore the rural and urban labor markets are separated. In the static model there are no links between the two labor markets. But in the dynamic model an adjustment function reallocates labor from the relatively low productive rural labor market to the urban region. Within the urban labor market labor is assumed to be completely mobile.

Value added prices

To simplify the treatment of intermediate goods we introduce a set of "value-added" prices, P_i^*. They are defined as the production cost of one unit of a commodity after deduction of the cost of intermediate inputs.

$$P_i^* = P_i - \sum_{j=1}^{5} P_j^D a_{ji} \qquad i = 1,\ldots,5 \qquad (32\text{-}36)$$

P_j^D are domestic prices. This set of prices will be discussed more fully when describing the treatment of exports and imports.

<u>Factor markets</u>

The demand for factors of production can be derived from the necessary conditions for profit maximization. Profit is defined in the four urban sectors as

$$\pi_j = P_j^* X_j - W_j L_j - Q_j K_j \qquad j = 2,\ldots,5$$

The value added price P_j^* takes into account the cost for intermediate goods. The capital stock is divided into buildings, B, and other capital equipment, M, machinery. In every sector we have assumed a constant proportion of buildings, Φ_i, and machinery $(1-\Phi_i)$. The annual rate of depreciation of these two types of capital is represented by ι_i (buildings) and $\varkappa_i$ (machinery). Following Johansen (1974) we define the concept user cost of capital, Q_j, which takes into account both depreciation and interest charges. Q_j is defined as

$$Q_j = P_2^D (C_j + \varkappa_j)(1-\Phi_j) + P_5^D (C_j + \iota_j)\Phi_j \qquad (53\text{-}56)$$

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

where C_j denotes the net return on capital.

The resulting first-order conditions are for the four urban sectors

$$\frac{W_j L_j}{P_j^* X_j} = \gamma_j \left(\frac{X_j}{h_j L_j A_j} \right)^{\rho_j} \qquad j = 2,\ldots,5 \qquad (38\text{-}41)$$

$$\frac{Q_j K_j}{P_j^* X_j} = \delta_j \left(\frac{X_j}{g_j K_j A_j} \right)^{\rho_j} \qquad j = 2,\ldots,5 \qquad (45\text{-}48)$$

The first-order conditions can be interpreted as demand equations in the factor market.

Total supply of labor, capital and land in agriculture is given and the production factors are assumed to be fully employed. We assume that factors of production are paid in correspondence with their marginal productivity. Using the concept of user cost of capital, we can define the profit.

$$\pi_1 = P_1^* X_1 - W_1 L_1 - Q_1 K_1 - rR_1$$

Value-added is divided among returns on labor (W_1L_1), capital (Q_1K_1), and land (rR_1). Optimizing with respect to labor and capital results in the following two equations.

$$\frac{W_1 L_1}{P_1^* X_1} = (1-\alpha)\gamma_1 \left(\frac{H_1}{h_1 L_1}\right)^{\rho_1} \tag{37}$$

$$\frac{Q_1 K_1}{P_1^* X_1} = (1-\alpha)\delta_1 \left(\frac{H_1}{g_1 K_1}\right)^{\rho_1} \tag{44}$$

The distinction between rural and urban regions is important when describing the factor markets. In a pure general equilibrium model factors of production are allocated in each period of time in such a way as to equalize factor returns. As has already been discussed it is necessary to elaborate on this point in our model.

First, there are two labor markets in the model, rural and urban, tied together in the dynamic model by net migration of the population from rural to urban areas. Thus two wages will be determined, so that supply and demand are matched in both markets. However the assumption of one urban wage does not reflect the large observed differences among wages in urban sectors. On the other hand, the wage structure is fairly stable over time.

The wages in the industries 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 transport subsectors have the highest wages (Jungenfelt, 1966, App. B, Table 6). This may be explained by a higher share of skilled labor in these sectors. Therefore, the second modification of the model ensures that the urban labor force is always allocated so that the urban wages remain in a certain constant proportion to each other.

$$W_j = \omega_j W_U \qquad j = 2,\ldots,5 \qquad (49\text{-}52)$$

W_j are sectoral wages and W_U is the average wage in the urban sector normalized to unity in the base year.

An alternative way to model the labor market would have been to explicitly introduce substitutability between different types of skilled labor. Such an approach is rather common in CGE models of developing countries (see for example Kelley and Williamson 1984). It is not possible to adopt that approach here because of data restraints.

The constraints on the wage equalization mechanism lend more realism to the model but do not move it away from neoclassical theory. Even though the labor force is not perfectly mobile, the dynamic model will incorporate migration to reallocate labor from a rural sector with low wages to an urban labor market with higher wages. By specifying an urban wage structure that is stable over time, the growth rates of wages are equalized among the urban sectors.

We make similar assumptions for the rates of return on capital as for wages. Urban and rural capital markets are separated in the static model. In the urban region we have assumed a fixed structure on rates of return among sectors. There is also reason to expect sectoral differences in the rate of return on capital, e.g., different risks connected with investments in the sectors, different degrees of monopolization in various branches, etc. The allocation of the capital stock among the four urban sectors is thus determined by the rate of return in such a way as to maintain a given sectoral structure over time,

$$C_j = \sigma_j C_U \qquad j = 2,\ldots,5, \tag{57-60}$$

where C_U is the average rate of return in the urban region, normalized at unity in the base year, and σ_j is a constant that reflects the sectoral structure. For a discussion of this formulation of sectoral structure of factor returns see Johansen (1974, p. 259).

The equilibrium equation in the urban capital market is

$$\sum_{j=2}^{5} K_j = K_U \tag{62}$$

The supply of labor has to be determined to complete the labor market. The supply is assumed to be a given share of the total population. But this share (total aggregated labor participation rate) differs between the two labor markets, and increases during the industrialization period. The share (p_j) is treated as an exogenous variable

$$L_j = p_j N_j \qquad j = A,\ U \tag{42-43}$$

The urban labor market-clearing equation is

$$\sum_{j=2}^{5} L_j = L_U \tag{61}$$

Household disposable income and saving

We separate households into two categories, rural and urban. Household income is generated in the rural area from three different factors, labor, land and capital, as well as remittances from emigrants. These remittances have often been neglected in studies of this period, but they are of a substantial magnitude (Lindahl, Dahlgren and Koch 1937, p. 588). In the model it is assumed that these remittances are sent to people living in rural areas since these are the main origins of the emigrants. The remittances are exogenously determined in the model.

Taxes are deducted from household income. As early as in the 1870s a large range of different taxes and duties existed in Sweden: various property taxes, a proportional income tax, a personal tax for adults independent of income, and so on (Lundsjö 1975, p. 41). These taxes are roughly described by a proportional tax on capital income, τ^c (returns on land in agriculture are included in the tax base), and on wages, τ^ℓ, in the model.

Private savings are derived from labor and capital income in both rural and urban sectors. We assume that some part of household expenditure is devoted to covering basic needs of the population. The labor force is thus assumed to save only from their "supernumerary" income, which is defined as

$$q_j = \sum_{i=1}^{5} b_{ij} P_i^D N_j \qquad j = A, U \qquad (63\text{-}64)$$

where b_{ij} is per capita subsistence consumption of commodity i in region j.

Different savings rates (s^{ℓ} and s^{c}) are assumed for labor and capital income. Household saving in the two regions can now be defined as

$$S_A = s^{\ell}[(1-\tau^{\ell})W_1L_1 + T - q_A] + s^{c}(P_1^{*}X_1 - W_1L_1)(1-\tau^{c}) \quad (92)$$

$$S_U = s^{\ell}[(1-\tau^{\ell}) \sum_{j=2}^{5} W_jL_j - q_U] + s^{c} \sum_{j=2}^{5} Q_jK_j(1-\tau^{c}) \quad (93)$$

Disposable household income spent on consumption is given by the following equations:

$$Y_A^{\ell} = [(1-\tau^{\ell})W_1L_1 + T - q_A](1-s^{\ell}) + q_A \quad (65)$$

$$Y_A^{c} = (1-\tau^{c})(P_1^{*}X_1 - W_1L_1)(1-s^{c}) \quad (66)$$

$$Y_U^{\ell} = [(1-\tau^{\ell}) \sum_{j=2}^{5} W_jL_j - q_U](1-s^{\ell}) + q_U \quad (67)$$

$$Y_U^{c} = (1-\tau^{c}) \sum_{j=2}^{5} Q_jK_j(1-s^{c}) \quad (68)$$

<u>Household demand</u>

We have chosen to specify one demand system for rural households and one for urban ones. In each sector we assume that each individual has a utility function of the type

$$U_j = \sum_{i=1}^{5} \beta_{ij} \log (D_{ij}/N_j - b_{ij})$$

Maximizing utility given a budget constraint will yield linear demand equations (Stone, 1954). In each region the demand for commodity i (D_i) is given by

$$P_i^D D_{ij} = N_j b_{ij} P_i^D + \beta_{ij}[(Y_j^{\ell} + Y_j^c) - q_j] \quad j = A, U \quad (69\text{-}78)$$

This functional form has been chosen because it is easy to handle and is also well suited to the analysis of the Engel effect which occurred during Swedish industrialization (see Chapter 2).

Imports and exports

As has already been discussed (see Chapter 2) foreign trade played a crucial role in Swedish industrialization. Depending on underlying assumptions about the links between domestic and foreign markets the specification of foreign trade in the model can be made in different ways.

When incorporating foreign trade in a multisectoral model it is common to make the small country assumption (Dervis, de Melo, Robinson, 1982). It means that the home country cannot influence the prices on the world market. The country's supply of goods is too small. However making the small country assumption causes some problems. First, there is the problem of specialization. If there is perfect competition, a technology which exhibits constant returns to scale and more tradable goods than factors of production, there will be specialization in equilibrium (Samuelson, 1953). Only as many tradables as there are factors of production will be produced and tradable goods will be either imported or exported. However in our model this problem does not occur. There are three tradables, agricultural goods and commodities produced in sectors 2 and 3, the export-oriented industries and the homemarket-oriented industries.

A second problem when opening a model for foreign trade is the problem of intra-industry trade. Looking at trade statistics one can observe exports and imports within the same trade classification. The intra-industry trade problem we face in our model. Both exports and imports occurred in the 19th century Swedish economy within the sectors we have defined (see input-output tables in Appendix B). One can allow for two-way trade by assuming less than perfect substitutability between imports and domestic products. This is the so-called Armington assumption (Armington, 1969). The hypothesis is that goods with the same classification but produced in different countries are not perfect substitutes.[3] But this assumption implies that the small country assumption is relaxed.

For agriculture and homemarket-oriented industries we make the Armington assumption in the model. Let us define a composite commodity, COM_i, which is a CES aggregation of imports, M_i, and domestically produced and supplied goods, $X_i - Z_i$ (exports of sector i are denoted by Z_i) denoted by DOM_i for simplicity.

$$COM_i = \bar{A}_i \left[\gamma_i M_i^{-\rho_i} + (1-\gamma_i) DOM_i^{-\rho_i} \right]^{-1/\rho_i}$$

where $\bar{A}_i$, γ_i and ρ_i are parameters.

With such a formulation one can assume different degrees of substitutability between the two components of COM_i.

The prices on the two components differ. The problem that a buyer now faces is how to divide a given amount COM_i between M_i and DOM_i to minimize cost. The optimal mixture can be derived by solving the cost-minimization problem:

$$\text{Min } COST_i = P_i DOM_i + P_i^W M_i$$

$$\text{s.t. } COM_i = \bar{A}_i \left[\gamma_i M_i^{-\rho_i} + (1-\gamma_i) DOM_i^{-\rho_i} \right]^{-1/\rho_i}$$

The following first order condition emerges:

$$\frac{M_i}{DOM_i} = \left(\frac{\gamma_i}{1-\gamma_i}\right)^{\mu_i} \left(\frac{P_i}{P_i^W}\right)^{\mu_i}$$

where $\mu_i = 1/(1+\rho_i)$ is the "trade-substitution" elasticity. P_i is the domestic production cost of good i and P_i^W is the world market price of good i. To simplify the expressions we assume a fixed exchange rate and normalize the domestic price system by setting the exchange rate to unity. In the base year commodities are defined such that relative prices are unity, therefore the constant part in the above equation will be identical to the observed share of import (denoted by $\bar{M}_i$ for simplicity) in that year. Thus we can rewrite the import equation

$$\frac{M_i}{X_i - Z_i} = \bar{M}_i \left(\frac{P_i}{P_i^W}\right)^{\mu_i} \qquad i = 1, 3 \qquad (85\text{-}86)$$

These are the import equations of sectors 1 and 3. The import shares thus depend on the relative prices between domestic production costs and world market prices as well as the magnitude of μ_i, the responsiveness of domestic demand to relative price changes.

Supply of commodity i on the domestic market emerges from two different sources, domestically produced goods and imports. The price on the composite good also consists of the two components. Domestic price P_i^D is defined in the model as[4]

$$P_i^D = \frac{M_i}{M_i + (X_i - Z_i)} P_i^W + \frac{X_i - Z_i}{M_i + (X_i - Z_i)} P_i \qquad i = 1, 3 \qquad (79\text{-}80)$$

With this specification the domestic price system will not be completely linked to the international prices. It will thus make the model less rigid. This is an important assumption made to allow for two-way trade in the model.

The problem with regard to the exports of sectors 1 and 3 is the mirror image of that for imports. If we assume that buyers in the world market are cost minimizers in the same way as the domestic buyers, we can derive their import functions (the home countries' export functions) in the same way as above. The resulting export functions will have the form

$$Z_i = \bar{Z}_i \left(\frac{P_i^W}{P_i}\right)^{\varepsilon_i} V_i \qquad i = 1, 3 \tag{88-89}$$

where V_i is an exogenous variable capturing the growth of the world market.

For the main Swedish export goods, i.e. commodities produced in sector 2, the export-oriented industries, we assume that terms-of-trade are given, i.e. the small country assumption is kept. This assumption implies that there is a perfectly elastic export demand. The domestic price of this sector is thus completely determined by the world market price

$$P_2^D = P_2^W. \tag{81}$$

Making this assumption and assuming the exchange rate to be unity, all prices are relative prices, expressed in terms of P_2.

Imports for sector 2 are simply assumed to be a constant fraction of domestic supply

$$\frac{M_2}{X_2 - Z_2} = \bar{M}_2 \tag{87}$$

Because domestic prices are completely determined from outside, importing will not change the price of commodity 2

$$P_2^D = P_2 \tag{82}$$

The exports from sector 4, the service sector, originate from the sub-sectors of transportation and commerce. The export revenues were the trade markups on exported goods for commerce, and the income earned by Swedish ships in foreign trade for transportation (more exactly net income, see Johansson 1967, p. 182). Exports from sector 4 are assumed to be determined as a fixed share of the total exports from sectors 1-3.

$$Z_4 = \nu \sum_{i=1}^{3} Z_i \qquad (90)$$

In sectors 4 and 5 there are no links between the domestic and foreign price systems. Consequently, there is no difference between domestic production costs and domestic prices.

$$P_i^D = P_i \qquad i = 4, 5 \qquad (83\text{-}84)$$

Discussing the specification of the foreign sector in the model, we finally have the constraint of current account:

$$F + T = \sum_{i=1}^{3} P_i^W M_i - \sum_{i=1}^{4} P_i Z_i \qquad (91)$$

As has already been discussed, we have assumed net capital inflow, F, and remittances, T, to be exogenous.

Savings, investment and market clearance

Only a few equations remain to complete the static model. First we have to determine total savings. Savings originate from three different sources: household savings, S_A and S_U (see eq. (92)-(93) on p.56), net foreign savings, F, and the savings undertaken by the government. Government expenditure in fixed prices, G, is assumed to be exogenous, but its income is determined by taxation. Government savings, S^G, are given by eq. (94).

$$S^G = \tau^{\ell} \sum_{j=1}^{5} W_j L_j + \tau^c \left(\sum_{j=2}^{5} Q_j K_j + P_1^* X_1 - W_1 L_1 \right) - P_4^D G \qquad (94)$$

Total savings are

$$S = S_A + S_U + S^G + F. \tag{95}$$

As we will show in Section 3.4, equality between total investment, I, and aggregated savings is fulfilled in the model

$$S = I$$

Gross investment expenditures are thus endogenously determined by savings in the model.

Because investment goods are produced in two different sectors, we simply divide total investment exogenously between sector 5 (ξ), and sector 2.

$$I_5 \; P_5^D = \xi I \tag{96}$$

$$I_2 \; P_2^D = (1-\xi) I \tag{97}$$

Finally, the conditions for commodity market equilibrium have to be specified.

$$X_1 = D_{1A} + D_{1U} + \sum_{j=1}^{5} a_{1j} X_j + Z_1 - M_1 \tag{98}$$

$$X_2 = D_{2A} + D_{2U} + \sum_{j=1}^{5} a_{2j} X_j + I_2 + Z_2 - M_2 \tag{99}$$

$$X_3 = D_{3A} + D_{3U} + \sum_{j=1}^{5} a_{3j} X_j + Z_3 - M_3 \tag{100}$$

$$X_4 = D_{4A} + D_{4U} + \sum_{j=1}^{5} a_{4j} X_j + G + Z_4 \tag{101}$$

$$X_5 = D_{5A} + D_{5U} + \sum_{j=1}^{5} a_{5j}X_j + I_5 \tag{102}$$

Gross national product is defined as

$$GDP = \sum_{i=1}^{5} P_i^D X_i - \sum_{i=1}^{5} \sum_{j=1}^{5} P_i^D X_{ij}. \tag{103}$$

The static model consists of 103 independent equations and 103 endogenous variables.

3.4 THE STATIC MODEL AND SAVINGS-INVESTMENT EQUALITY

In this section we will show that the static model fulfils the saving-investment identity.

By multiplying the equations for commodity market equilibrium (equations 98-102) by P_i^D and using equations (79-84) we can substitute for P_i^D to obtain the following five equations:

$$P_1X_1 - \sum_{j=1}^{5} P_1^D a_{1j}X_j = P_1^D D_{1A} + P_1^D D_{1U} + P_1Z_1 - P_1^W M_1$$

$$P_2X_2 - \sum_{j=1}^{5} P_2^D a_{2j}X_j = P_2^D D_{2A} + P_2^D D_{2U} + P_2Z_2 - P_2^W M_2 + P_2^D I_2$$

$$P_3X_3 - \sum_{j=1}^{5} P_3^D a_{3j}X_j = P_3^D D_{3A} + P_3^D D_{3U} + P_3Z_3 - P_3^W M_3$$

$$P_4X_4 - \sum_{j=1}^{5} P_4^D a_{4j}X_j = P_4^D D_{4A} + P_4^D D_{4U} + P_4Z_4 + P_4^D G$$

$$P_5X_5 - \sum_{j=1}^{5} P_5^D a_{5j}X_j = P_5^D D_{5A} + P_5^D D_{5U} + P_5^D I_5$$

We sum over all five sectors i and get

$$\sum_{i=1}^{5} P_iX_i - \sum_{i=1}^{5}\sum_{j=1}^{5} P_i^DX_{ij} = \sum_{i=1}^{5} P_i^DD_{iA} + \sum_{i=1}^{5} P_i^DD_{iU} + \sum_{i=1}^{4} P_iZ_i -$$

$$- \sum_{i=1}^{3} P_i^WM_i + P_2^DI_2 + P_5^DI_5 + P_4^DG \qquad \text{(I)}$$

The next step is to start with the profit-functions used in Section 3.3 when deriving conditions for profit maximizing. In equilibrium we know that profit is zero and therefore we can rewrite the profit function as

$$P_1^* = W_1 \frac{L_1}{X_1} + Q_1 \frac{K_1}{X_1} + r \frac{R_1}{X_1}$$

$$P_i^* = W_i \frac{L_i}{X_i} + Q_i \frac{K_i}{X_i} \qquad i = 2,\ldots,5$$

Using the definitions of net prices (eq. 32-36) and multiplying each equation by X_1, we get

$$P_1X_1 = \sum_{j=1}^{5} P_j^DX_{j1} + W_1L_1 + Q_1K_1 + rR$$

$$P_iX_i = \sum_{j=1}^{5} P_j^DX_{ji} + W_iL_i + Q_iK_i \qquad i = 2,\ldots,5.$$

We now sum over all five sectors, i. To simplify we express remuneration to capital and land in agriculture as

$$P_1^*X_1 - W_1L_1$$

We then obtain

$$\sum_{i=1}^{5} P_i X_i - \sum_{i=1}^{5} \sum_{j=1}^{5} P_j^D X_{ji} = \sum_{i=1}^{5} W_i L_i + \sum_{i=2}^{5} Q_i K_i + $$
$$+ P_1^* X_1 - W_1 L_1 \qquad \text{(II)}$$

Using equations (I) and (II) we get an expression for investments.

$$P_2^D I_2 + P_5^D I_5 = \sum_{i=1}^{5} W_i L_i + \sum_{i=2}^{5} Q_i K_i + P_1^* X_1 - W_1 L_1 -$$
$$- \sum_{i=1}^{5} P_i^D D_{iA} - \sum_{i=1}^{5} P_i^D D_{iU} - \sum_{i=1}^{4} P_i Z_i +$$
$$+ \sum_{i=1}^{3} P_i^W M_i - P_4^D G$$

A summation of equations (69)-(78) over all goods will give

$$\sum_{i=1}^{5} P_{ij}^D D_{ij} = Y_j^\ell + Y_j^C \qquad j = A, U$$

Substituting for Y_j^ℓ and Y_j^C using equations (63-68) yields

$$P_2^D I_2 + P_5^D I_5 = s^{\ell}\left[(1-\tau^{\ell})W_1L_1 + T - q_A\right] + s^c(1-\tau^c)(P_1^*X_1 - W_1L_1) +$$

$$+ s^{\ell}\left[(1-\tau^{\ell}) \cdot \sum_{j=2}^{5} W_jL_j - q_U\right] + s^c(1-\tau^c) \sum_{j=2}^{5} Q_jK_j +$$

$$+ \tau^{\ell} \sum_{j=1}^{5} W_jL_j + \tau^c\left[\sum_{j=1}^{5} Q_jK_j + P_1^*X_1 - W_1L_1\right] -$$

$$- P_4^D G + \sum_{i=1}^{3} P_i^W M_i - \sum_{i=1}^{4} P_iZ_i - T \qquad \text{(III)}$$

The first part of the right hand side is household savings in rural and urban areas (equations 92-93), the second is government savings (eq. 94) and the last part foreign savings (eq. 91). Total investments are thus equal to total savings in the model

$$P_2^D I_2 + P_5^D I_5 = S_A + S_U + S_G + F \qquad \text{(IV)}$$

An alternative way to close the model would be to exclude the balance of current account (91) and instead include equation (IV) in the model. In such a case rewrite equation (III) with the help of equations (92-94) and (IV). We get

$$F + T = \sum_{i=1}^{3} P_i^W M_i - \sum_{i=1}^{4} P_iZ_i, \qquad \text{(91)}$$

which is the balance of current account.

3.5 THE DYNAMIC MODEL

Introduction

When simulating our model system over time we solve the static model for each year. One solution influences the next and we need to specify this impact. These dynamic links thus tie a sequence of solutions into a time path which should capture the main features of the Swedish economic development during the last part of the 19th century. We have based our specification mainly on empirical considerations.

Some of the exogenous variables in the static model are endogenous in the dynamic model. Those variables which change value from one static solution to another and depend on variables endogenous in the static model are endogenous in our dynamic model. These variables are rural and urban capital stocks, rural and urban population, emigration and rural-to-urban migration.

Investment allocation

The allocation of investment is obviously of crucial importance in the process of industrialization. Sandberg (1978) argues that the early development of a functioning capital market is one important reason why Sweden developed so fast during the 19th century. However Gårdlund (1947) shows that the need for industrial capital was met to a great extent by internal sources through retained profits, and the external credit facilities were mainly supplied by private persons with a close connection to the companies. The growth of financial intermediaries made the capital market increasingly more efficient.

It is difficult to model a capital market with what we have called dual characteristics. On the one hand, there existed a growing and efficient financial market which allocated an increasing part of the savings. On the other hand, an important part of the savings was never intended for, or allocated by, any financial market. Savings were invested by the same persons who created them, especially in agriculture. Therefore, to assume a perfect capital market and rate of return equalization among all sectors seems to be inappropriate.

To model the dual nature of the capital market we divide available private savings into one part which is invested in the region where it is saved and one part, the savings fund SF, which is allocated by the market

$$SF = (1 - z)(S_A + S_U) \qquad (104)$$

The allocation of the savings fund is determined by the relative user cost of capital between rural and urban sectors. Investment in the two regions is determined by the following two equations

$$I_A = zS_A + \frac{Q_1}{\sum_{i=1}^{5} Q_i} SF \qquad (105)$$

$$I_U = S^G + zS_U + \frac{\sum_{i=2}^{5} Q_i}{\sum_{i=1}^{5} Q_i} SF + F \qquad (106)$$

Government saving and foreign capital are assumed to be invested in the urban region. If there is an equalization of the user cost of capital among the sectors, 1/5 of the savings fund will be allocated to agriculture and 4/5 to the four urban sectors. This mechanism is totally ad hoc, but the purpose is to incorporate a mechanism in the model which allocates a larger share of the investments redistributed via the market to the region with an increased relative rate of return on capital. However, we have assumed that 20 percent of private savings are allocated via the market in the dynamic simulations of the model. Thus the main assumption made about the allocation of investment between rural and urban regions is that savings are mainly invested in the region of origin.

Growth of capital stock

The capital stock in period t consists of the stock in period t-1 plus gross investment minus depreciation:

$$K_j(t) = K_j(t-1) + I_j(t-1) - [\iota_j \Phi_j + \varkappa_j (1-\Phi_j)] K_j(t) \qquad j = A, U \qquad (107\text{-}108)$$

where ι_j, $\varkappa_j$ are different depreciation rates of the two types of physical capital that compose the capital stock. The sector's share of buildings and plants in the capital stock is denoted by Φ_j. The reason for this formulation is that the investments are produced in two different sectors.

Productivity increase

The technological parameters in the production functions, g_j and h_j, change over time according to exogenously determined growth rates:

$$g_j(t) = g_j(t-1)\exp(\chi_j) \qquad j = 1,\ldots,5 \qquad (109\text{-}113)$$

$$h_j(t) = h_j(t-1)\exp(\lambda_j) \qquad j = 1,\ldots,5 \qquad (114\text{-}118)$$

The growth rate (χ_j and λ_j) differs among the different sectors.

Growth of cultivated land

The area of cultivated land, R_1, grows over time in accordance with the historical pattern,

$$R_1(t) = R_1(t-1)\exp(\eta) \tag{119}$$

where η is the growth rate.

World market growth

The growing world market has an independent influence on the growth of Swedish exports of sectors 1 and 3. It is simply assumed that they grow at an exogenous rate (ψ_j).

$$V_j(t) = V_j(t-1)\exp(\psi_j) \qquad j = 1, 3 \qquad (120\text{-}121)$$

Migration

In the model rural-to-urban migration and emigration to the United States are explicitly modelled. Economic factors are assumed to be the determining factors in migration. The theoretical foundation for this hypothesis lies in human capital theory (Sjaastad 1962, Greenwood 1965). Migration is looked upon as an investment, and it is the present value (PV) of an investment in migrating from one region to another that determines whether the move was made or not. The present value of migrating from region A to region U can be defined as

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

where Y refers to income in the different regions, COL to the costs associated with residence in the two localities, and r to 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 that maximizes PV will be chosen. This hypothesis is also supported by empirical studies on Swedish emigration (Hamberg 1976). However there are several studies that also stress the general economic conditions (business cycles) in the U.S. for explaining the waves of emigration.

When specifying the migration functions in the model, we rely indirectly on the theoretical conclusions by separating out economic factors, especially wages, as important determinants of migration. However, the explicit form we have chosen reflects the econometric studies that have been undertaken. Rural-to--urban migration and emigration are determined by two equations in the model. In the first equation total outmigration from agriculture is determined.

$$O/N_A = m1 - m2W_A + m3W_2 + m4B_{US} \qquad (122)$$

O is total outmigration from rural regions, N_A population in agriculture, B_{US} index of business cycles in the United States. The parameters are denoted by m1 to m4. Total outmigration includes both migrants to the urban regions and to the United States.

The second equation determines the allocation between the two in-migration regions (the urban region and the U.S.)

$$E/O = m5 - m6\,\frac{W_{US}}{W_2} + m7B_{US} \qquad (123)$$

Emigration is denoted by E, the wage in the U.S. by W_{US} and m5 to m7 are parameters.

These two equations should not be interpreted as an assumption of two steps of emigration, first to the urban region and then to the U.S. It is only a technical way of capturing three streams of migrants, rural-urban, rural-U.S., and urban-U.S. All migration variables are expressed in net migration terms.

Population growth

Population growth is endogenous in the dynamic model

$$N_A(t) = N_A(t-1)(1+\zeta_A) - O(t-1) \quad (124)$$

$$N_U(t) = N_U(t-1)(1+\zeta_U) + O(t-1) - E(t-1) \quad (125)$$

As was shown in Chapter 2, fertility and mortality differed between rural and urban regions. This demographic dualism is captured by region specific rates of net natural increase in population, ζ_A and ζ_U.

Labor participation rate

The total aggregate labor-participation rate differs between rural and urban regions and shows an increase during the industrialization period. The difference between rural and urban participation can be partly explained by different age structures. During the entire 1870-1914 period the share of the population below the age of 15 was higher in rural areas. For example, during the 1870s, 35 percent of the rural working population were under 15 years of age as compared to 30 percent of the urban population (Thomas 1941, p. 47). This does not, however, explain all the differences between rural and urban labor participation rates. The rate even differs within the working-age group (defined as the part of the population that is over 15 years of age). How important the age distribution above 15 is for this difference cannot be determined because of the lack of information about age-specific participation ratios. Among men, no significant difference existed between urban and rural areas (around 80 percent in both areas in the 1870s). However, for women in the rural areas the rate remained constant at 17 percent during the pre-war period while in urban areas it increased from 28 percent in the 1870s to 43 percent in 1920 (Silenstam, 1970, p. 103).

The labor participation rate, p_j, is an aggregation of the working-age share of the population, sex distribution, and sex-specific labor participation rates within the working cohorts. The sex and age-specific labor participation ratios did not remain stable during the period of study, but the other components did. To incorporate these changes, aggregated labor participation rates increased in the dynamic model by an exogenously determined growth rate, Θ_j.

$$p_j(t) = p_j(t-1)\exp \Theta_j \qquad j = A, U \qquad (126\text{-}127)$$

3.6 IMPLEMENTATION OF THE MODEL

An extensive data base has been assembled in order to implement the model. This section provides a brief overview of the data base, model estimation, and testing. A detailed discussion can be found in Appendix B.

The first decision required for the numerical implementation concerns time. The 1870s are commonly looked upon as the beginning of Swedish industrialization; the year 1871 is picked for this study because some crucial data series do not exist before that year. This year also exemplifies both an upswing of the business cycle - although the peak of the general business activity was still to come (see Jörberg, 1961) - and a downswing of the first emigration cycle.

For a system as large as this model, estimating all the coefficients with conventional econometric methods would be an overwhelming, virtually impossible task. For some variables no time series exist. Instead, because of the historical nature of the study and the nature of a computable general equilibrium model, procedures that have been developed in recent years will be used. The procedure is to assemble a data set that is consistent with the general equilibrium conditions. Once assembled, many parameters can be estimated from these conditions. This data set has the property that supply and demand for different products and factors of production balance. Many different sources have been used to collect data, corrections have been made to obtain consistent classifications, and all value figures have been deflated to our base year. Parts of the data set have been assembled in the form of input-output tables for six years (1871, 1880, 1890, 1900, 1910 and 1913). The input-output table for 1871 is the basic data set when implementing the model.

We have followed the common procedure of implementing CGE-models when the model is calibrated to the base year 1871. Calibrating the model means to make the model able to reproduce the basic data set as a solution of the static model, see Mansur and Whalley (1984). Quantities are chosen such that all relative prices are unity in the base year. Making this assumption and using the structure of the model we can calculate many of the parameters. However, some crucial parameters such as elasticities are also needed. They have been obtained either from other studies or simply set to a certain value.

Once the model is fully specified, it can be solved for a general equilibrium. The solution algorithms used are developed by Andras Por at IIASA and apply the Newton method.

The base solution in 1871 is the first step in testing the model. Because the parameters are estimated so that the data base is reproduced in the base year solution, this step is only a technical test of the model. Since the model involves a rather complicated nonlinear relationship among various behavioral variables, sectoral production, distribution of factors of production, and consumption patterns could easily differ from actual base year data. Nevertheless all commodity prices are modelled as unity in the base year and none of the prices differ more than one percent from unity in the model replication. The rest of the endogenous variables are close to actual base-year data with the exception of one which differs only slightly more than one percent. Thus the model satisfies a technical test: it reproduces the data base of the benchmark year. The base year solution is displayed in Table C.1 in App. C. But the crucial test is the next step: the predictive accuracy of the model. It will be discussed in Chapter 5.

NOTES

1) The mathematical statement of the model can be found in Appendix A. Equation numbers correspond to the mathematical statement.

2) There are two different approaches to solve this problem in multi-sector models: either to define sector specific factors of production or to assume less than perfect substitutability between domestic imported goods, see Bergman (198) and Dervis, de Melo and Robinson (1982).

3) Another approach in treating intra-industry trade is to assume monopolistic competition.

4) The theoretically correct specification of the domestic price is the cost function corresponding to the CES-aggregation of COM:

$$P_i^D = \frac{1}{A_i}\left[\gamma_i^{\mu_i} P_i^{W\,(-\mu_i)} + (1-\gamma_i)^{\mu_i} P_i^{(1-\mu_i)}\right]^{1/1-\mu_i}$$

4. Comparative Static Simulations

4.1 INTRODUCTION

Our CGE model has a rather complex structure. Before describing the dynamic simulations it is important to know how strongly different variables interact and what drives the model. It is especially important to know how various exogenous variables affect the endogenous variables.

This chapter is devoted to that analysis. We will calculate all the comparative static effects of marginal changes in each exogenous variable in the model. For expositional purposes the model has been reduced to 35 equations and linearized (see Appendix D). In the next section (4.2) we will describe the approach of this chapter in some detail. In Section 4.3 we present and discuss the comparative static results.

However, comparative statics based on this approach cause two problems. First, only very small changes in the exogenous variables are evaluated since the behaviour of the model is only valid locally. Therefore one should interpret these results very cautiously in the context of actual historical conditions. In the historical context changes in crucial variables are often discrete rather than marginal.

Second, even for the case of a very small change in a given variable between two years, the cumulative effects over a longer period of time could be significant. The short run and long run behaviour of the model may therefore differ significantly. We will illustrate the significance of these problems with a comparison between two static experiments using the non-linear and the linear versions of the model (Section 4.4).

4.2 LINEARIZING THE MODEL

Following Johansen's (1974) approach we can obtain the desired comparative statics in terms of changes in the growth rates of different variables.

The model can be expressed as

$$\begin{aligned} F^1(y_1, \ldots, y_n; x_1, \ldots, x_m) &= 0 \\ &\vdots \\ F^n(y_1, \ldots, y_n; x_1, \ldots, x_m) &= 0, \end{aligned} \qquad (4.1)$$

where the n endogenous variables are denoted by y and the m exogenous variables are denoted by x.

According to the implicit-function theorem, we know that during certain assumptions there exists a local neighbourhood of (x_1^0, ..., x_m^0) in which y_i are implicitly defined functions of the exogenous variables x_i, ..., x_m. The model (4.1) can thus be expressed as

$$\begin{aligned} y_1 &= f^1(x_1, \ldots, x_m) \\ &\vdots \\ y_n &= f^n(x_1, \ldots, x_m), \end{aligned}$$

or in matrix notation

$$Y = f(X).$$

A first-order Taylor expansion yields

$$Y \equiv Y^0 + dY \approx f(X^0) + Df(X^0)dX, \tag{4.2}$$

where $Df(X^0)$ is the Jacobian matrix of f at X^0.

$$Df(X^0) = \begin{bmatrix} \frac{\partial f^1(X^0)}{\partial x_1} & \cdots\cdots\cdots & \frac{\partial f^1(X^0)}{\partial x_m} \\ \cdot & & \cdot \\ \cdot & & \cdot \\ \cdot & & \cdot \\ \frac{\partial f^n(X^0)}{\partial x_n} & \cdots\cdots\cdots & \frac{\partial f^n(X^0)}{\partial x_m} \end{bmatrix}$$

Expressing equation (4.2) in relative growth r^tes we obtain

$$Y\dot{Y} \approx Df(X^0)X\dot{X}$$

$$\dot{Y} \approx Y^{-1}Df(X^0)X\dot{X} \tag{4.3}$$

In order to derive an explicite expression for this approximation we treat the variables in the basic model as functions of time and totally differentiate the model at a specified point (t_0) where $y = y^0$ and $x = x^0$ and express the variables in relative growth rates. It yields

$$\sum_{i=1}^{n} \frac{\partial F^k}{\partial y_i} \frac{dy_i(t_0)}{dt} = -\sum_{i=1}^{m} \frac{\partial F^k}{\partial x_i} \frac{dx_i(t_0)}{dt} \qquad k = 1, \ldots, n \tag{4.4}$$

Define $\frac{dy}{dt}/y = \dot{y}$ and $\frac{dx}{dt}/x = \dot{x}$, and let $(Y^0, X^0) = (y_1^0, y_2^0, \ldots, y_n^0; x_1^0, x_2^0, \ldots, x_n^0)$. Equation (4.4) can now be rewritten as

$$A(Y^0, X^0)\dot{Y} = B(Y^0, X^0)\dot{X},$$

where A, the endogenous variables Jacobian of F, is an n x n matrix of the coefficients of the endogenous variables and B an n x m matrix of the coefficients of the exogenous variables. $\dot{Y}$ is a column vector containing the n endogenous variables and $\dot{X}$ is a vector of the m exogenous variables.

By the implicit functions theorem A is non-singular. The solution to the system is

$$\dot{Y} = A^{-1}B\dot{X} = T(Y^0, X^0)\dot{X}. \qquad (4.5)$$

The n x m matrix T is the solution matrix.

Equation (4.5) is thus an explicite expression to the linear approximation (4.3). Expressed in terms of equation (4.3) the error of approximation is the missing remainder term which is needed to turn that equation into an equality. The importance of this error in our analysis will be discussed in the last section of this chapter. But before that we will look at the solution matrix T.

The elements of T have the following interpretation. Element i in the vector $\dot{Y}$ in equation (4.5) is equivalent to

$$\dot{y}_i = \sum_{j=1}^{m} t_{ij}\dot{x}_j$$

The element in row i and column j of T is denoted by t_{ij}. t_{ij} thus represents the elasticity of a change in the exogenous variable $\dot{x}_j$. The solution matrix t_{ij} is displayed in Table 4.1. It contains all the comparative statics in which we are interested. The results will be further discussed in the next section.

4.3 COMPARATIVE STATICS IN THE LINEAR MODEL

In this section we will work through Table 4.1 and discuss the results. Some of the observations are necessarily superficial, since the figures result from an interaction of all relationships in the model. Nevertheless the exercise will increase our understanding of the operation of the model.

Effects of a change in urban capital accumulation[1]

Column 4 displays the effects of urban capital accumulation. The upper section of the column describes the effects on the allocation of the labor force. Since the total labor force is merely redistributed, a weighted average of the rate of change sum to zero:

$$\sum_{i=2}^{5} \left(\frac{L_i}{L_U}\right) \dot{L}_i = \dot{L}_U = 0$$

Sectors 3 and 4, homemarket-oriented industries and services, decrease while sectors 2 and 5, export-oriented industries and building and construction, increase their use of labor.

The next section in the column, rows 5 to 8, describes the effects on capital allocation. Since

$$\sum_{i=2}^{5} \left(\frac{K_i}{K_U}\right) \dot{K}_i = \dot{K}_U,$$

the weighted average must equal unity. Three of the four sectors have coefficients greater than one. However, sector 4 dominates the use of urban capital using almost 90 percent of the urban capital in the base solution, and its low coefficient offsets the others.

Table 4.1 The solution matrix T

Endogenous variables	Exogenous variables: 1 $\dot{K}_A$	2 $\dot{N}_A$	3 $\dot{R}_1$	4 $\dot{K}_U$	5 $\dot{N}_U$	6 $\dot{g}_1$	7 $\dot{h}_1$	8 $\dot{g}_2$	9 $\dot{h}_2$	10 $\dot{g}_3$	11 $\dot{h}_3$	12 $\dot{g}_4$	13 $\dot{h}_4$	14 $\dot{g}_5$	15 $\dot{h}_5$	16 $\dot{P}_1^W$	17 $\dot{P}_3^W$	18 $\dot{V}_1$	19 $\dot{V}_3$	20 $\dot{F}$	21 $\dot{G}$
1 $\dot{L}_2$	−0.0161	−0.0701	−0.0327	−0.0897	1.3503	−0.0161	−0.1149	0.1127	0.1737	−0.0415	0.0367	0.1776	0.3009	−0.1153	−0.1790	−0.4793	−1.4577	−0.2503	−0.0841	0.0964	−0.0809
2 $\dot{L}_3$	0.1514	0.5766	0.3020	−0.0727	0.0956	0.1514	1.0567	−0.1253	−0.5052	−0.1833	−0.5872	0.0649	0.0802	0.1163	0.2878	−0.4787	0.9836	−0.1102	0.0435	−0.0051	0.0262
3 $\dot{L}_4$	0.2103	0.9497	0.4198	−1.0388	0.3446	0.2103	1.4688	−0.0610	−0.1073	−0.0132	0.0348	−0.9918	−0.4928	0.0272	0.1039	−0.4717	−0.0360	−0.1482	0.0071	0.0145	0.2512
4 $\dot{L}_5$	−0.7294	−3.1947	−1.4550	2.9481	3.3352	−0.7294	−5.0905	0.1634	0.5869	0.2608	0.4164	2.5798	0.9886	−0.0547	−0.3638	2.3684	0.8640	0.8219	0.0362	−0.1489	−0.6522
5 $\dot{K}_2$	−0.1185	−0.5326	−0.2364	1.3849	0.9122	−0.1185	−0.8271	−0.1553	0.9562	−0.0204	0.0073	1.0840	0.3393	−0.2360	−0.5006	−0.2834	−1.4912	−0.1790	−0.0876	0.0811	−0.2301
6 $\dot{K}_3$	0.0120	−0.0524	0.0247	1.6356	−0.4561	0.0120	0.0869	0.0359	−0.0536	−0.5560	−0.2251	1.2395	0.1284	−0.0932	−0.2515	−0.2007	0.9582	−0.0114	0.0392	−0.0247	−0.1704
7 $\dot{K}_4$	0.0129	0.0614	0.0257	0.9274	−0.0629	0.0129	0.0897	0.0063	−0.0768	0.0206	0.0057	−0.1468	−0.0353	0.0269	0.0539	0.0126	0.0645	0.0077	0.0045	−0.0004	0.0278
8 $\dot{K}_5$	−0.7800	−3.4286	−1.5537	4.3502	2.4914	−0.7800	−5.4347	0.4991	1.7992	0.2790	0.3602	3.7255	1.0239	−1.0612	−1.4354	2.3146	0.6209	0.8306	0.0286	−0.1726	−0.8184
9 $\dot{X}_1$	0.0997	0.7003	0.2000	0	0	0.0997	0.70	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 $\dot{X}_2$	−0.0355	−0.1580	−0.0715	0.3360	1.2670	−0.0355	−0.2503	0.2519	1.1323	−0.0375	0.0311	0.3499	0.3082	−0.1382	−0.2402	−0.4420	−1.4641	−0.2367	−0.0848	0.0935	−0.1093
11 $\dot{X}_3$	0.0857	0.2801	0.1713	0.7327	−0.1645	0.0857	0.5995	−0.0493	−0.2923	0.1125	0.1121	0.6186	0.1029	0.0175	0.0335	−0.3476	0.9716	−0.0636	0.0415	−0.0143	−0.0665
12 $\dot{X}_4$	0.0601	0.2738	0.1199	0.4573	0.0346	0.0609	0.4195	−0.0098	−0.0840	0.0125	0.0126	0.4121	0.0944	0.0270	0.0658	−0.0103	0.0405	−0.0296	0.0051	0.0007	0.0813
13 $\dot{X}_5$	−0.7447	−3.2652	−1.4847	3.3706	3.0809	−0.7447	−5.1942	0.2645	0.9523	0.2663	0.3995	2.9251	0.9993	−0.0567	0.0120	2.3522	0.7908	0.8246	0.0339	−0.1561	−0.7023
14 $\dot{Y}$	0.1442	0.7605	0.2876	−0.2917	0.1524	0.1442	1.0063	0.0373	0.2082	−0.0227	−0.0059	−0.3055	−0.0179	0.0178	0.0583	−0.2989	−0.1370	−0.0925	−0.0012	−0.0055	0.0543
15 $\dot{D}_1$	0.0808	0.8408	0.1616	−0.1446	0.1080	0.0808	0.5656	0.0011	0.0202	−0.0166	−0.0164	−0.1368	−0.0265	0.0105	0.0250	−0.2100	−0.0970	−0.0622	−0.0017	−0.0044	0.0233
16 $\dot{D}_2$	0.2134	0.8253	0.4262	−0.2930	−0.0625	0.2134	1.4913	0.0235	0.1455	−0.0335	−0.0216	−0.3043	−0.0280	0.0339	0.0919	−0.4887	−0.3732	−0.1406	−0.0032	−0.0116	0.0611
17 $\dot{D}_3$	0.1890	0.7150	0.3774	−0.0339	−0.1259	0.1890	1.3206	−0.0012	0.0056	0.0061	0.0135	−0.0737	0.0010	0.0334	0.0838	−0.4705	−0.4308	−0.1278	−0.0037	−0.0142	0.0316

Table 4.1 cont.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
		$\dot{K}_A$	$\dot{N}_A$	$\dot{R}_1$	$\dot{K}_U$	$\dot{N}_U$	$\dot{g}_1$	$\dot{h}_1$	$\dot{g}_2$	$\dot{h}_2$	$\dot{g}_3$	$\dot{h}_3$	$\dot{g}_4$	$\dot{h}_4$	$\dot{g}_5$	$\dot{h}_5$	$\dot{P}_1^W$	$\dot{P}_3^W$	$\dot{V}_1$	$\dot{V}_3$	$\dot{F}$	$\dot{G}$
18	$\dot{D}_4$	0.05 75	0.22 14	0.11 41	0.74 89	−0.04 46	0.05 75	0.39 91	−0.04 18	−0.25 71	−0.01 15	−0.02 32	0.69 26	0.13 61	0.07 25	0.16 50	−0.04 89	−0.06 12	−0.01 52	−0.00 22	−0.01 59	−0.05 79
19	$\dot{M}_1$	0.00 80	0.31 62	0.01 52	0.31 17	0.36 44	0.00 80	0.05 27	0.02 88	0.10 91	0.03 62	0.05 23	0.25 48	0.09 44	−0.00 40	0.00 62	−0.66 53	0.12 34	0.00 90	0.00 40	0.00 55	−0.03 00
20	$\dot{M}_2$	−0.24 93	−1.13 68	−0.49 58	1.52 44	1.47 93	−0.24 93	−1.73 37	0.28 56	1.15 26	0.13 81	0.21 28	1.50 36	0.54 58	−0.31 42	−0.65 09	0.68 28	0.16 48	0.26 44	0.01 07	−0.07 20	−0.34 53
21	$\dot{M}_3$	0.30 96	1.28 35	0.61 80	−1.56 35	0.39 87	0.30 96	2.16 23	0.17 12	0.95 22	−0.23 83	−0.19 77	−1.42 75	−0.13 50	0.02 26	0.10 82	−0.53 73	−3.69 94	−0.23 53	−0.00 09	0.00 82	0.19 63
22	$\dot{Z}_1$	0.26 98	1.20 13	0.54 34	−0.83 09	−0.97 14	0.26 98	1.90 40	−0.07 67	−0.29 09	−0.09 64	−0.13 93	−0.67 92	−0.25 17	0.01 06	−0.01 66	1.77 37	−0.32 90	0.72 23	−0.01 08	−0.01 46	0.08 00
23	$\dot{Z}_2$	0.12 45	0.57 45	0.24 61	−0.55 34	1.10 82	0.12 45	0.85 99	0.22 66	1.11 72	−0.16 89	−0.10 48	−0.51 35	0.13 03	−0.00 65	0.06 72	−1.28 38	−2.68 32	−0.61 18	−0.15 62	0.21 73	0.06 74
24	$\dot{Z}_3$	−0.09 56	−0.43 07	−0.19 07	1.01 44	−0.24 85	−0.09 56	−0.66 73	−0.09 70	−0.54 76	0.15 50	0.13 72	0.90 33	0.10 57	−0.00 19	−0.03 18	0.07 52	2.05 28	0.07 33	0.99 83	−0.01 01	−0.11 57
25	$\dot{Z}_4$	0.15 16	0.68 63	0.30 29	−0.49 75	0.29 97	0.15 16	1.05 99	0.09 70	0.50 00	−0.11 49	−0.09 35	−0.43 51	0.00 29	−0.00 05	0.03 05	−0.15 46	−1.46 85	−0.11 05	0.00 02	0.12 01	0.05 44
26	$\dot{P}_1$	−0.10 79	−0.48 05	−0.21 74	0.33 24	0.38 86	−0.10 79	−0.76 16	0.03 07	0.11 63	0.03 86	0.05 57	0.27 17	0.10 07	−0.00 42	0.00 66	0.29 05	0.13 16	0.11 11	0.00 43	0.00 58	−0.03 20
27	$\dot{P}_3$	0.04 78	0.21 53	0.09 54	−0.50 72	0.12 42	0.04 78	0.33 37	0.04 85	0.27 38	−0.07 75	−0.06 86	−0.45 16	−0.05 28	0.00 09	0.01 59	−0.03 76	−0.02 64	−0.03 67	0.00 09	0.00 50	0.05 79
28	$\dot{P}_4$	0.21 26	0.95 31	0.42 57	−1.62 29	0.03 17	0.21 26	1.49 01	0.10 08	0.62 14	−0.02 93	0.00 66	−1.54 86	−0.25 90	−0.06 81	−0.13 39	−0.62 15	−0.26 61	−0.18 51	−0.00 10	0.00 90	0.18 05
29	$\dot{P}_5$	0.27 22	1.21 40	0.54 76	−1.11 84	−0.74 95	0.27 22	1.91 81	0.47 20	2.09 35	−0.02 96	−0.04 62	−0.24 88	−0.04 23	−1.05 97	−2.48 30	−0.98 38	−0.61 64	−0.27 04	−0.00 87	−0.00 88	0.11 47
30	$\dot{W}_1$	0.00 54	−1.17 42	−0.15 69	0.73 00	0.48 77	0.00 54	−0.63 31	0.01 34	0.00 22	0.05 55	0.07 06	0.62 85	0.17 38	0.02 05	0.06 39	0.46 03	0.21 29	0.17 62	0.00 57	0.00 57	−0.07 49
31	$\dot{W}_U$	−0.03 62	−0.16 59	−0.07 12	0.79 24	−0.43 01	−0.03 62	−0.24 86	0.16 26	0.57 19	0.01 35	−0.02 58	0.65 83	0.03 07	−0.00 05	−0.03 54	0.00 04	−0.12 47	0.01 36	−0.00 38	−0.01 25	−0.09 33
32	$\dot{C}_1$	−1.66 13	0.49 25	−0.15 69	0.73 00	0.48 77	−0.66 13	0.03 36	0.01 34	0.00 22	0.05 55	0.07 06	0.62 85	0.17 38	0.02 05	0.06 39	0.46 03	0.21 29	0.17 62	0.00 57	0.00 57	−0.07 49
33	$\dot{C}_U$	0.05 04	0.23 45	0.09 78	−1.61 81	1.02 27	0.05 04	0.00 34	−0.41 61	−1.51 75	−0.01 77	0.07 18	−1.31 08	−0.02 95	1.05 83	2.53 24	0.09 45	0.29 38	−0.00 10	0.00 93	0.02 83	0.19 24
34	I	−1.03 83	−4.56 26	−2.06 56	4.33 41	4.44 67	−1.03 83	−7.22 39	0.92 31	3.74 26	0.41 45	0.62 29	4.47 36	1.59 54	−1.16 88	−2.49 53	3.08 85	0.71 51	1.15 39	0.04 69	−0.27 61	−1.12 11
35	GNP	0.07 87	0.48 39	0.15 77	0.32 32	0.52 23	0.07 87	0.55 22	0.10 64	0.46 10	0.04 99	0.08 59	0.28 65	0.15 87	−0.08 29	−0.15 73	−0.10 13	0.07 38	−0.02 53	0.00 39	0.00 08	−0.01 02

The effects on production, shown in rows 10 to 13, are related to the reallocation of factors of production. Sector 5 shows the highest relative increase in production. This sector is relatively small. Its share of urban value-added is only about 13 percent. According to our data base only intermediate goods and investment goods are produced in this sector. Thus, the high figure reflects the large increase in investment. Roughly one third of the investment goods are produced in sector 5.

After building and construction sectors 3, 4, and 2 follow in order of size of change coefficient. The ranking can be partly ascribed to different elasticities of demand. However, one should remember that domestic supply is also affected by changes in foreign trade, as seen in rows 20, 21, 23 and 24. Exports of sector 2 decrease and its imports increase. The opposite changes occur for sector 3. Thus, taking foreign trade adjustments into account, the change in domestic supply for sector 2 is larger than the coefficient on production indicates. For sector 3 the corresponding coefficient is lower.

Rows 27 to 29 show the effects of urban capital accumulation on urban relative prices. Remember that the relative price of sector 2 is used as a numeraire. All urban prices decrease.

When the urban capital stock expands, marginal productivity of urban capital falls and marginal productivity of urban labor increases. Factor price changes reflect these effects, but they are also influenced by the urban relative price changes. The consequences for urban factor prices are displayed in rows 31 and 33. The return on capital decreases while the urban wage increases.

The rural sector is influenced via the commodity market. Demand grows for agricultural goods as inputs in urban production processes. Agricultural output remains the same because there is no reallocation of factors of production between the urban and rural sectors. However, there is a supply effect in the agricultural commodity market. Import of agricultural goods increases and export decreases, thus increasing domestic supply. The net effect of the changes in supply and demand is an increase in the price of agricultural goods. This increase affects factor returns in agriculture. Both wage and return on capital rise by the same percentage, as seen in rows 30 and 32. The increase in rural factor returns increases disposable income, demand and savings of rural households.

Note that aggregate urban disposable income diminishes because the net effect of the changes in urban and rural sectors is a decrease, as seen in row 14. Thus the aggregate income effect lowers demand. However, relative prices change and modify the income effect. Private demand increases for the commodity (No. 4) whose price decreases most. Rows 15 to 18 display the total effect on demand.

In row 34 we can see that investments increase when urban capital expands. This reflects an equivalent rise in savings because investments are determined by savings. This effect reflects the net change in total savings. There is an increase in the savings of the government and the rural households, but private urban savings decrease. The increase in government savings does not reflect larger revenues but rather lower expenditures. Tax income diminishes, but the decrease in expenditures is larger. In quantity terms government expenditures are exogenous but the relative price, P_4, diminishes, causing government expenditures to decrease.

Effects of increasing urban population growth

Column 5 in Table 4.1 describes the effects of an increase in urban population. The first part of this column shows the effects on factor allocation and production. The effects on capital by urban sectors are purely redistributional. The weighted average of the sector changes equals zero. With respect to labor reallocation we know that

$$\sum_{i=2}^{5} \left(\frac{L_i}{L_u}\right)\dot{L}_i = \dot{L}_u$$

and thus the weighted average of these figures will equal unity.

Applying a theorem associated with Rybczynski helps in understanding the direction of urban reallocation. In a two-sector model with unchanged commodity prices, an expansion in one factor of production results in an absolute decline in the commodity intensive in the use of the other factor (Rybczynski 1955, Jones 1965).

In Table 4.2 the urban sectors are arranged according to their factor intensities. One can observe that sector 5, building and construction, is the most labor intensive sector and it displays the highest growth when the urban labor force increases. The change in output of the remaining three sectors does not follow the factor intensities. However, the picture changes if we aggregate the four sectors into two. Sectors 2 and 4, services and export-oriented industries, and sectors 3 and 5, homemarket-oriented industry and building and construction, are summed together, respectively. The most labor-intensive sectors (sectors 3 and 5) display the largest change in the growth rate when the labor force increases. Its change in weighted output using share of aggregated output as weights is 0.52 compared to 0.37 for the less labor-intensive sectors. However, in the case of an increase in urban capital the labor-intensive sector is still the one with the largest change in output. Thus the pattern of reallocation does not follow the predictions of the Rybczynski theorem in this case. The theorem assumes unchanged commodity prices. As we have seen prices are flexible in our model. Thus the general-equilibrium effects are so strong that the results deviate from those predicted by the theorem.

Total income increases when urban population grows. With respect to the changes in the pattern of demand (rows 15 to 18) we note that there is an increase only in the demand for agricultural goods. All other demands decrease. Increasing population has a negative effect on the income spent on goods other than agricultural goods because of increases in subsistence consumption of commodity 1. The set of parameters used assumes the largest subsistence consumption of agricultural goods. The increase in urban population and the higher price on agricultural goods decrease supernumerary income despite an increase in total income. Therefore we observe a decline in private demand for all urban goods (including the numeraire commodity produced in the export oriented sector) despite an increase in total income.

Table 4.2 Reallocation among the urban sectors

Sectors	Sectoral/ /capital/ /labor ratio	Percentage change in the growth rates of sector production for a change in: Urban population		Urban capital	
Services	6.41	0.03	0.37 [1]	0.46	0.46
Export oriented ind.	1.11	1.27		0.18	
Home market-oriented ind.	0.73	-0.16	0.52	0.73	1.02
Building and construction	0.12	3.08		3.37	

1) The weights used are the share of each sector out of total production of each aggregation.

Rows 19 to 25 indicate the effects of a change in urban population growth in imports and exports. We observe an increase in exports of the main exporting sector, sector 2. However, the imports of this sector also increase. Import of sector 2 is a fixed share of domestic supply

$$M_2 = \bar{M}_2(X_2 - Z_2).$$

If the growth rate of output is larger than for export, import will increase as well. This is the mechanism behind the increase in sector 2 imports.

The effects are reversed for changes in factor prices for an increase in the urban population compared with an accumulation of urban capital. Capital now becomes relatively more scarce, and the relative factor price on capital in the urban sector increases.

The qualitative effects of an increase in urban population on the rural sector are similar to the case of an increase in urban capital. Rural factor prices increase by the same percentage, keeping the ratio constant. The value of the marginal product of rural production factors changes only because of changes in commodity prices. Observe that the coefficient for agricultural price is lower than that for rural factor prices. However, agricultural price is not the only price influencing rural factor prices. Relative price changes of urban goods also affect the cost situation in agriculture through the use of intermediate goods. It is the net change in these (value-added) prices that is relevant when analyzing how changes in commodity markets affect factor returns.

Effects of growth of factors of production in agriculture

Columns 1 (K_A), 2 (N_A) and 3 (R_1) indicate the effects of growth in the factors of production used in agriculture. Labor has the strongest output-creating effect, followed by land and capital, as seen in row 9. All the indirect effects on the rest of the economy are similar in these three cases. Increase in population gives rise to the strongest effects throughout. On the rural side note the fall in the price of agricultural goods, even in the case of larger population. Remember that we have specified a certain minimum level of per capita agricultural consumption. A larger population gives rise to increased demand, but the increase in supply is large enough to counteract larger demand.

The only differences among these three cases are the effects on returns to the factors of production in agriculture (rows 30 and 32). An increase in population diminishes marginal productivity of labor. This effect is strengthened by the change in prices. Agricultural price decreases and all urban commodity prices go up. Changes in both regions reduce the value-added price of agriculture, and consequently the rural wage decreases substantially. As expected, the return on capital increases. When agricultural capital grows, the mechanisms are the same. Return on capital falls and the wage rate increases. An expansion of land acreage increases productivity of both labor and capital proportionally. However, the commodity price changes counteract the increased productivity. Rural factor returns fall.

Turning to the effects on exports and imports of sector 1 (row 19 and 22) we observe a larger growth in both. The relative price of commodity 1 falls. The export figure thus reflects an increased competitiveness of agriculture. Remember that it is the import's share of domestic supply that is determined by relative prices.

$$\frac{M_1}{X_1 - Z_1} = \overline{M}_1 \left(\frac{P_1}{P_1^W} \right)^{\mu_1}$$

Thus a fall in the relative price, ceteris paribus, decreases import. But it could be counteracted by larger domestic supply. This is the mechanism behind the increase in sector 1 imports.

The effects on the urban sectors operate via the commodity markets. Rural terms of trade deteriorate when factors of production in agriculture increase. This reflects an increase in rural demand for urban intermediate goods, but also aAn increase in urban demand. The positive price effect in the urban region increase urban income in terms of food and a larger share can be used for consumption of urban goods. Changes in demand cause a reallocation of urban capital and labor. The reallocation is purely redistributional and the weighted averages of the changes sum to zero. Production of sectors 3 and 4, homemarket-oriented industry and services, increases and production diminishes in sectors 2 and 5, export-oriented industry and building and construction. This reflects different demand elasticities, different demand for urban intermediate goods in agriculture and decreasing investment (row 34).

Effects of technical progress in agriculture

The effects of technical changes in agriculture are shown in columns 6 and 7 of Table 4.1. Row 9 shows the effects on output. Labor-augmenting technical growth has a much stronger effect on output than capital-augmenting technical change. The increase in agricultural output causes a large fall in the price of agricultural goods and counteracts the positive effect on agricultural factor prices of the increased productivity. A one-percent increase in labor-augmenting technical change decreases the price of agricultural goods by 0.76 percent and the agricultural wage by 0.63 percent. The same effect occurs on the return on capital when technical growth is capital-augmenting. Note that the fall in value-added price in sector 1 is larger than the decrease in agricultural production cost, P_1.

The different effects on rural factor prices of capital or labor-augmenting technical change are the only differences between these two experiments. Moreover, the effects of technical change are very similar to the effects of growth in agricultural factors of production. Column 6 (capital-augmenting technical change) and column 1 (expansion of the rural capital stock are identical, except for rural rent. Rural rent is of course higher when there is technical change because of the increase in the marginal productivity of capital. However, the direction of change is the same in columns 7 (labor-augmenting technical change) and 2 (increase in rural population), but the magnitude differs considerably. The reason is the demand effect of a larger population. Subsistence consumption increases, thus decreasing supernumerary income and causing another pattern of demand. The case of labor-augmenting technical change can thus be interpreted as the consequences of the supply effect of an increased population (except the coefficient on rural wage). Adding the direct demand effect of a larger population, we get the results shown in column 2.

The effects on the urban sectors of technical change in agriculture operate through the commodity markets. The price changes initiate a reallocation among the urban sectors. There is exactly the same pattern of reallocation with technical change in agriculture as with growth in a rural factor of production. The growth of agricultural production increases demand for intermediate goods produced in the urban sectors. The sectors with a relatively strong forward linkage to agriculture (sectors 3 and 4) increase their production. Production of the other two sectors diminishes. The redistribution of the urban factors of production is displayed in rows 1 to 8. Relative factor prices change with urban reallocation. Urban wage decreases and remuneration to capital increases. These changes also cause a fall in savings and investment. The decrease in saving out of wage income (rural as well as urban) counteracts the increase in savings out of capital income. Remember that investment is completely determined by savings. Thus there is a fall in the rate of investment.

Effects of technical progress in the urban sectors

Columns 8 to 15 show the effects of technical change in the urban sectors. It is clear that large reallocations of factors of production and changes in output occur. Rows 10 to 13 indicate the effects on production. As expected production increases in the sectors which experience technical change.

However, there is one exception. Increased technical efficiency causes a drop in the production in sector 5, building and construction. This reflects a substantial decrease in investment, as seen in row 34. Sector 5 produces mainly investment goods, which are also produced in sector 2, export-oriented industry. The production of this sector also diminishes in this case. Sectors 3 and 4 increase their output. The decrease in investment is caused by a decrease in saving, which is a consequence of the reallocation of factors of production among the urban sectors. Capital moves from sectors 2, 3 and 5 to sector 4, services. The rate of return on capital is highest in sector 5 and much lower in sector 4. Remember that in the urban sector there is a fixed sectoral structure of capital remuneration. Even though the average rate of return on capital increases in the urban sector the reallocation of capital causes total urban profits to decrease. Thus total saving, investment and production of sectors 5 and 2 decrease when there is technical growth in sector 5. We also notice that it is only in these two cases that investment and GNP decrease when technical efficiency increases.

Generally, technical growth causes a diminished use of the factors of production that are becoming more efficient (row 1 to 8). The only exception is labor-augmenting technical growth in sector 2, which increases the employment of labor in sector 2. In this case there is a very substantial increase in saving and investment. The increase in demand for the production of sector 2, the export-oriented industry, as well as sector 5, building and construction, thus causes both capital and labor to move to this sector despite the larger efficiency of its labor.

Rows 27 to 29 show the effects on urban relative prices. The price of the product of a sector which experiences technical change will always decrease. In the case of technical change in sector 2 (the sector producing the numeraire good) we notice that all prices increase, implying a relative decrease in the price of goods produced in sector 2. Moreover the price fall is generally greater for the product produced in the sector experiencing technical change than in the other sectors.

All changes in agriculture with technical change in the urban sector occur indirectly via the commodity markets. Agricultural production is unaffected. Increase in production and reallocation among the urban sectors changes demand for agricultural goods, both for final demand and as inputs in urban production. Deliveries of intermediate goods are rather important. In the case of the largest increase in the price of agricultural goods (capital-augmenting technical growth in the service sector, column 12), we also observe the strongest combined effect on production of sectors 2 and 3. These two sectors have the strongest foreward linkage to agriculture.

Because the effects on agriculture only operate through the commodity markets, rural factor prices are only influenced by changes in the value-added price. Thus changes in the wage rate and rate of return on capital should be identical in all cases with technical change in the urban sector. Rows 30 and 32 also show a constant relative factor price in agriculture.

Effects of changes in the world market

Four experiments analyzing the effects of changes in the world market are displayed in columns 16 to 19. Two of the experiments concern changes in the world market for agricultural goods (a price rise and and increased demand with constant prices) and two experiments concern the effects of similar changes on the world market for goods produced in sector 3, homemarket-oriented industry.

Column 16 describes the effects of an increase in the world market price of agricultural goods. The initial effect is an increase in agricultural exports and decrease in imports. The increase in exports is larger than the decrease in imports. Agricultural production is fixed and thus the domestic supply of agricultural goods falls. Reflecting this change in supply, the price on agricultural goods increases. The price changes in the urban sector are generally negative (rows 27-29). Thus, there is an improvement in the terms of trade of the agricultural sector. Rural factor prices reflect the improvement and rise.

As in the previous cases with exogenous changes in the rural sector, effects on the urban region operate entirely via commodity markets. In this case there is a decrease in urban income because of deteriorating terms of trade. In columns 1 to 13 the coefficients for the resulting urban reallocation are described. Production of sector 2, 3 and 4 diminishes and production of sector 5 increases. The resulting changes in productivity of factors of production and prices determine new relative factor prices. Urban wage falls and return on capital increases.

Comparing the effects of a world price rise on agricultural goods (column 16) with the effects of a growth of the world market without any terms-of-trade effect (column 18), we note that almost all changes are in the same direction, but not equally strong.

The other two exogenous changes on the world market initially affect homemarket-oriented industry (columns 17 and 19). A rise in world market price results in a large drop in imports and an increase in exports of commodity 3. Domestic supply decreases but in this case there is a reallocation effect that increases production. Resources are attracted to sector 3 and production rises. The reallocation among the urban sectors is purely redistributional and thus the weighted averages of the changes in urban factor allocation sum to zero.

Notice that even in this case there is a terms-of-trade decrease for the urban sector, although the initial change occurs in an urban sector instead of the rural sector. The demand for agricultural goods as inputs increases because of a reallocation of factors of production to urban sectors with strong intermediate linkages to agriculture. Thus the price on agricultural goods increases despite a decrease in final demand (row 15).

There are some differences between the result of an increase in world market price of commodity 3 (column 17) and that associated with growth of the world market without any change in world market price (column 19). The main effects are the same, although the magnitude differs. The increase in exports of commodity 3 is just half that of a change in world market price. However, the decrease in imports is very small compared with the large change in the previous case. The changes in supply and demand result in this case in a price increase instead of a decrease when the world market price rose.

Effects of a change in net capital inflow

Net capital inflow (F) is exogenous in the model. Effects of a change in this variable are displayed in column 20. There is an outflow of capital in the base year, 1871. An increase in F thus indicates a larger export surplus and capital outflow. Total saving falls and there is also a fall in investment. The reallocation that follows diverts resources from sector 5 to the other urban sectors. Generally, the effects are small in this case.

Effects of increased government consumption

Government consumption is exogenous in the model. The consequences of a change are displayed in column 21. The initial effect in this case is an increased demand for goods produced in sector 4. Labor and capital are attracted to this sector. Production of services is rather labor intensive and the increase in employment of labor is thus larger than the change in capital. Government consumption is expressed in fixed prices. But the price is endogenous. Thus, an increase in government expenditure is in this case caused both by an increased consumption in terms of quantities but also by a price rise on commodities produced in sector 4 (row 28). There is no government budget constraint built into the model. Government incomes (taxes) are endogenous. This results in a fall in net government saving. Total saving decreases as well as investment. The change in demand for investment goods explains the large reduction in production for sector 5. The net impact on the economy of larger government expenditures is a fall in GNP. Resources are moved to less productive sectors.

4.4. DIFFERENCES BETWEEN THE NON-LINEAR AND THE LINEAR MODEL

A purpose of this study is to analyze not only marginal but discrete changes in exogenous variables. Therefore it is important to know how significant the non-linearities in the basic model are. We have therefore compared some of the comparative static results using the linear version of the model (L) with corresponding experiments solving the complete non-linear model (N-L). Two such experiments are compared: an increase in rural population and an increase in the urban capital stock. We have increased N_A by 6.92 percent (corresponding to an increase in total population of 5 percent) and K_U by 10 percent for the non-linear model. The effects of these runs are displayed in Table 4.3 together with the corresponding experiments with the linear version of the model. The non-linear results are divided by 6.92 and 10, respectively. If there are only minor differences between these pair of experiments the linear approximation of the basic model is good in these cases.

A change in rural population

The initial effects are almost of the same magnitude for the N-L and the L model. The slight non-linearity of the production function for agriculture makes the growth of output somewhat lower in the N-L case. Nevertheless, the effects on the commodity market are much stronger in the N-L model than in the L model. Price of agricultural goods falls by almost 0.8 percent compared to 0.5 percent. Differences in the response of rural factor prices to these changes are consistent with the changes in relative commodity prices. In the N-L model the fall in the rural wage is much stronger and the increase in return on capital not as strong as in the L case.

On the supply side, the change in domestic supply ($X_1 + M_1 - Z_1$) is less in the N-L model. Exports increase by almost 2.2 percent (compared to 1.2 percent) and import is negative in the N-L case. The different signs on imports of commodity 1 are caused by a much stronger price effect and a less pronounced increase in domestic supply. On the demand side changes in all three components influencing the demand for commodity 1 indicate a greater fall in the commodity price in the N-L model than in the L model. The increase in private consumption is lower and the fall in intermediate demand (from sectors 2 and 3 together) is larger in the N-L case.

We can observe a generally higher price level in the urban sectors of the L model. The urban relative prices increase. This increase results from the larger agricultural demand for urban intermediate goods. Aggregate income increases more in the L model than in the N-L model. Thus there has to be an adjustment in the distribution of urban factors of production and relative urban factor prices. In the N-L model there are slight increases in both the wage and return on capital. On the other hand the urban wage decreased in the L model and the change in return on capital is positive but small. However, the relative factor price (C_U/W_U) increases in both models, although the change in the linear version is somewhat larger than in the non-linear model. Capital becomes relatively more expensive and there is a tendency in the urban sectors to substitute capital for labor. We conclude that the general pattern of reallocation in the urban region is similar in both models, but the magnitude differs.

There is one strange result of the non-linear model. Since the production functions in the urban sectors display constant returns to scale, a certain percentage change in output should be accompanied by the same percentage change in factor use, given constant relative factor prices. If relative factor prices also change, substitution increases the factor intensity of the less expensive factor. Therefore we should observe a larger increase in the relatively cheaper factor when output increases, and a smaller decrease in the factor when output decreases. This applies to both the linear model and the non-linear model except for sector 2. In this sector output diminishes but labor decreases more than capital. However, the difference is very small, 0.0034 of a percentage point, and might thus be explained by the margin of error when solving the non-linear model.

Four of the eight differences in sign between the N-L and the L model occur in exports and imports. The difference in effects is reasonable considering the different price responses in the two versions of the model.

Table 4.3 Comparative statics in the non-linear (N-L) and the linear (L) version of the model, change in percent.

Endogenous variable	1% increase in rural population (N_A)		1% increase in urban capital (K_U)	
	N-L	L	N-L	L
$\dot{X}_1$	0.6884	0.7003	0	0
$\dot{X}_2$	-0.5606	-0.1580	0.6110	0.3360
$\dot{X}_3$	0.1664	0.2801	0.7171	0.7327
$\dot{X}_4$	0.0790	0.2738	0.5927	0.4573
$\dot{X}_5$	-0.1754	-3.2652	0.9746	3.3706
$\dot{P}_1$	-0.7836	-0.4805	0.5945	0.3324
$\dot{P}_3$	-0.0363	0.2153	-0.2697	-0.5072
$\dot{P}_4$	0.5748	0.9531	-1.2093	-1.6229
$\dot{P}_5$	0.3429	1.2140	-0.3178	-1.1184
$\dot{W}_1$	-1.4246	-1.1742	0.9687	0.7300
$\dot{W}_U$	0.3733	-0.1659	0.2869	0.7924
$\dot{C}_1$	0.1175	0.4925	0.9618	0.7300
$\dot{C}_U$	0.4022	0.2345	-1.6848	-1.6181
$\dot{L}_2$	-0.5639	-0.0701	0.4447	0.0897
$\dot{L}_3$	0.2156	0.5766	0.1195	-0.0727
$\dot{L}_4$	0.2167	0.9497	-0.4247	-1.0388
$\dot{L}_5$	-0.1738	-3.1947	0.5889	2.9481
$\dot{K}_2$	-0.5605	-0.5326	1.3751	1.3849
$\dot{K}_3$	0.1112	-0.0524	1.4601	1.6356
$\dot{K}_4$	0.0362	0.0614	0.9504	0.9274
$\dot{K}_5$	-0.1795	-3.4286	1.9648	4.3502
$\dot{Y}$	0.1285	0.7605	0.1727	-0.2917
$\dot{D}_1$	0.7063	0.8408	-0.0524	-0.1446
$\dot{D}_2$	0.1407	0.8253	0.1888	-0.2930
$\dot{D}_3$	0.1599	0.7150	0.3348	-0.0339
$\dot{D}_4$	-0.1365	0.2214	1.0426	0.7489

(cont.)

$\dot{M}_2$	0.0325	-1.1368	0.6488	1.5244
$\dot{M}_3$	0.0063	1.2835	-0.5173	-1.5635
$\dot{Z}_1$	2.1616	1.2013	-1.3436	-0.8309
$\dot{Z}_2$	-0.9565	0.5745	0.5832	-0.5534
$\dot{Z}_3$	0.0731	-0.4307	0.5620	1.0144
$\dot{Z}_4$	0.1620	0.6863	-0.0500	-0.4975
$\dot{I}$	-0.0708	-4.5626	0.9401	4.3341
$\dot{GNP}$	0.1829	0.4839	0.1442	0.3232

A change in urban capital stock

In the second part of Table 4.3 we have displayed the results of an increase in the urban capital stock. The effects are generally very similar between the N-L and L models in this case. However, there are some differences.

The reallocation within the urban region is somewhat different in the two models. In both cases the largest increase occurs in sector 5, followed by sectors 3, 2 and 4 in the N-L model, and by sectors 3, 4 and 2 in the L model. The reallocation is accompanied by a change in relative factor prices. Return on capital falls because of both diminishing marginal productivity and a fall in commodity prices. The urban wage increases. There are some differences in magnitude between the N-L and the L models. However, the change in relative factor price (C_U/W_U) is close in both models, increasing by roughly 2 percent.

The stronger substitution effect in the L model is indicated by the change in employment of factors of production. There is more intensive use of capital in all urban sectors. In sector 4 (and sector 3 in the L model) the effect of substitution is stronger than the need for increased employment because of greater production. Employment of labor diminishes. In all urban sectors (both in the L and N-L models) the increase in capital usage is larger than the change in labor employed. Observe that this is the case also in sector 2 of the non-linear model. In the previous case there was an odd effect in this sector, but now, when the change in relative factor prices is larger, the sector behaves as expected.

In the L model commodity 2 becomes relatively more expansive than in the N-L case (there is a price fall for the other urban commodities). Therefore private consumption falls in this case in contrast to a small increase in the N-L model.

In the agricultural sector the effects occur via the commodity markets. The larger urban production increases demand for intermediate goods, which is offset by a decrease in private demand. The net effect is an increase in the price of agricultural goods. The commodity price changes is the only effect that influences rural factor prices. Thus, we would expect identical changes in the wage and return on capital. Note that the changes are very close both in the linear and the non-linear cases. The differences in the N-L model can be attributed to the margin of error when solving the model.

The conclusion we can draw from comparing the non-linear and the linear models is that the same mechanisms work in both models. However, the magnitudes are quite different in the two cases even when the change in an exogenous variable is limited to 10 percent.

Concluding remarks

The differences in the comparative static experiments for the two versions of the model are likely to be sensitive to the non-linearities.[2] Thus one should be very careful when interpreting the results discussed in section 4.3. They are only valid locally. When analyzing marginal changes in exogenous variables the effects are those previously discussed (Section 4.3). But larger changes in the exogenous variables cause our model to behave differently.

In the remaining part of this study (Chapters 5 and 6) we use our basic model to analyze the effects of certain exogenous shocks on Swedish industrialization. These are large rather than marginal. We also want to generate dynamic simulations of the model. Substantial changes in the exogenous variables are accumulated in such simulations. The linear version of our model is inadequate for quantifying the effects in such cases. Therefore we have implemented the complete non-linear model for these simulations.

NOTES

1) In this section a change in a variable refers to a change in the growth rate of a variable even though it is not spelled out everytime.

2) Another possibility is that different solution techniques involve different rules of approximations and thus cause differences. In this case the non-linear model is solved by an algorithm implemented on a Vax computor. The linear model is solved by inverting a 35 x 35 matrix and multiplying it by a 35 x 21 matrix. The package used is implemented on a Prime computer. Naturally there are different margins of error which might explain some of the differences we have noted. We have tested the accuracy by multiplying the inverse with the matrix of origin. The indentity matrix is obtained with a precision of 13 decimals. Another possible source of divergence is the different levels of reduction. In the non-linear case the entire model (103 equations) has been solved, but in the linear case the model was reduced to 35 equations. If there is a possible margin of error in every equation, the potential for error is larger in the non-linear model.

5. The Base Simulation 1871–1890

5.1 INTRODUCTION

Our hypotheses of Swedish industrialization were developed in the previous chapters and a model was formulated to analyze certain aspects of the development of Sweden. Before the model can be used for analysis with counterfactual simulations, it has to be tested. The crucial test of the model as a relevant analytical tool is whether it can reproduce the historical trends during the period of study.

CGE models are becoming more and more common. However very few have been evaluated by testing the accuracy of prediction.[1] Since the purpose of modelling varies, so does the necessity of testing the models empirically. Even in those studies where CGE models have been evaluated against actual data, there are few guidelines for choosing test criteria. There are no well-developed and generally accepted criteria in the literature to test a CGE model. Therefore the borderline distinguishing a good model from a bad one must be determined subjectively. The lack of accepted criteria emphasizes the importance of a thorough discussion of the performance of the model to motivate the credibility of counterfactual analysis.

In the literature on forecasting models, on the other hand, test criteria are developed (Theil, 1965). Some of these tests (for example goodness-of-fit tests and tests of turning-points) can easily be used to evaluate simulation models in historical research.

One way of evaluating the plausibility of the model is to use a "goodness-of-fit" measure. Suppose we want to compare how well the model predicts the GNP figures year by year. Assume A(t) are the observed and P(t) are the predicted values. A linear regression equation could then be estimated:

$$P(t) = \hat{\alpha} + \hat{\beta}\ A(t)$$

If the model exactly generates historical figures, $\hat{\alpha} = 0$, $\hat{\beta} = 1$ and $R^2 = 1.0$. Evaluation thus consists of standard statistical tests of the hypotheses that $\hat{\alpha} = 0$ and $\hat{\beta} = 1$.

Another test in this context is the turning-point criterion. For many of the time series in this study there are no turning-points. However, some crucial variables do display turning-points. Therefore, an analysis of the turning-points is also useful for judging the quality of the model. When it is relevant we will discuss this aspect.

However, one should be careful when applying such tests. Comparing annual figures we cannot expect a good fit. Our CGE model is intended for long term growth rather than short term fluctuations. Therefore the result of such tests will be influenced and worsened by short term fluctuations caused by the business cycles. However, we have undertaken some goodness-of-fit tests on annual data and will show the results. But they should be looked upon with much caution.

Our main intention is to compare average growth rates for different variables. Because of data constraints we are not able to look at all endogenous variables in the model. The model should have a better accuracy predicting them than the annual figures. But even in this case we cannot avoid the influence of the business cycle completely. Where in the business cycle was the starting year 1871 and in what phase of a cycle was the year 1890 where we terminate our simulations?

In this chapter, the base simulation 1871-1890 undertaken with our non-linear model will be evaluated.

5.2 BASE RUN SIMULATION 1871-1890

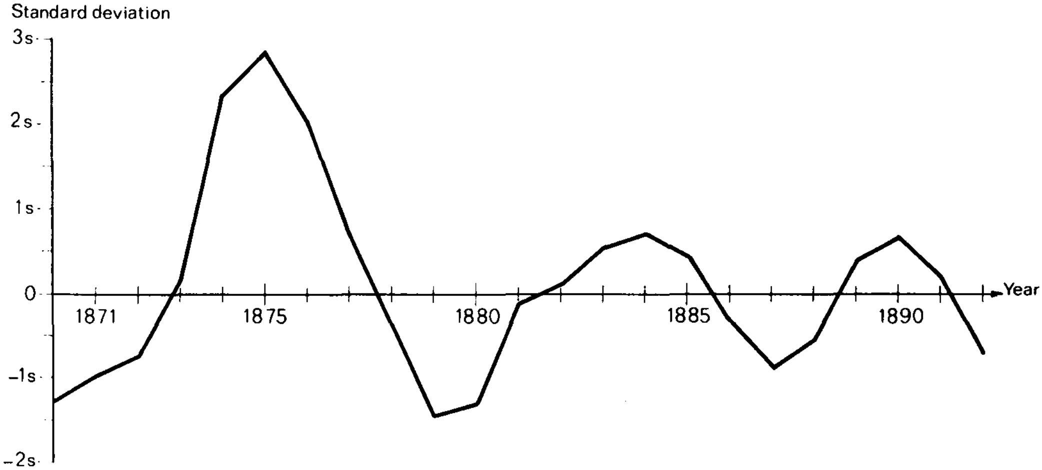
Business cycles and GNP growth

From 1871 to 1890 Sweden underwent its first phase of industrialization. The 1870s was a period of rapid growth, especially for export-oriented industries, sawmills and steelworks. During the 1880s growth was somewhat slower.

The period covers almost three business cycles with peaks in 1875, 1884, 1890 and troughs in 1879 and 1887, see Figure 5.1.[2] The starting year 1871 and the terminating year 1890 are troublesome from this point of view. Our period of study starts almost in a trough and ends in the peak of a business cycle. The reason for terminating the study in 1890 is the lack of data. For some of the variables there exist no data between the years of censuses 1870, 1880 and 1890. Therefore, we have finished the analysis in 1890 and also divided the period into two parts, 1871-1880 and 1880-1890, when discussing the simulation results. But, when looking at the results one should keep in mind the business cycles of the period.

The pattern of GNP is displayed in Figure 5.2. When comparing the two trajectories one has to remember that the model does not allow any excess capacity. It is not designed to capture business cycles. Therefore the model simulates growth of potential GNP.

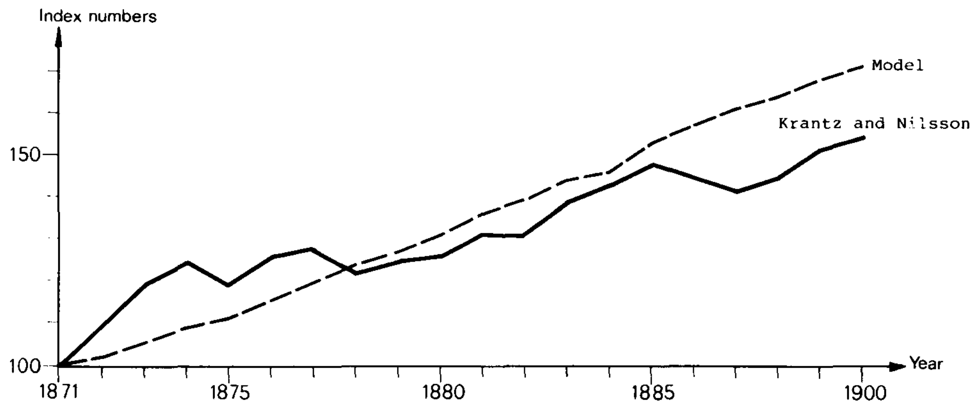
Figure 5.1 Business Cycle 1870-1892



s = standard deviation

Source: Thomas (1941), Table 53, p. 191.

Figure 5.2 Gross National Product 1871-1890



Source: Krantz and Nilsson (1975).

The model underestimates the capacity during the first part of the period, and by growing faster than the reported figures probably overestimates it towards the end of the 1880s. The average annual growth rate of GNP during the period of study is 2.3 percent according to the historical data presented by Krantz and Nilsson (1975). The model simulates an annual growth rate of 2.8 percent.

Table 5.1 compares the historical records with the performance of the model.

Table 5.1 GNP growth rates (average annual growth rates)

	Krantz and Nilsson	Model
1871-1890	2.3	2.8
1871-1880	2.6	3.0
1880-1890	2.0	2.7

Source: Krantz and Nilsson (1975).

The same tendency occurs even though the model shows a faster rate of growth. The annual growth rate is 2.8 percent between 1871 and 1890, 3 percent during the 1870s and 2.7 percent during the 1880s. The model does not predict such a large retardation as the historical records. But looking just at growth rates between two years hides the development during the period. Therefore we have compared the annual growth rates between average value of GNP during the 1870s with the average GNP of the 1880s. The decline in this case is 0.3 percent both in the model and in the historical figures.

The annual data on GNP can be used for a "goodness-of-fit" test of the performance of the model. Following the discussion in the previous section, the GNP figures generated by the model can be denoted by P(t) and the Krantz and Nilsson series by

A(t). An estimated linear regression between these two series yields

$$P(t) = \underset{(70.27)}{-67.11} + \underset{(0.53)}{1.53}\ A(t), \qquad R^2 = 0.89$$

The figures in parenthesis are standard errors. By ordinary significance test the hypothesis that the intercept is zero and the slope is unity cannot be rejected at a 99 percent level of significance.

Judging from these results the overall performance of the model is acceptable. But deviations between the two series of GNP figures do exist and examination of the sectoral growth rates indicates some of the reasons for discrepancies.

Sectoral growth rates

The sectoral growth rates for value added are displayed in Table 5.2. The historical figures are taken from Krantz and Nilsson (1975). They do not separate manufacturing into different industry branches. Therefore sector 2 and sector 3 in the model (the export-oriented industry and the homemarket-oriented industry) are added. The performance of the model is fairly close to observed figures, but some of the differences require some explanation.

Table 5.2 Sectoral growth rates of value added (fixed prices, annual rates)

	Agriculture		Manufacturing		Services		Building & Constr.	
	K-N	M	K-N	M	K-N	M	K-N	M
1871-1890	1.3	1.8	3.6	3.7	2.2	3.4	2.0	5.1
1871-1880	1.8	1.9	2.5	3.7	2.7	3.2	5.3	7.4
1880-1890	0.9	1.7	4.5	3.6	1.7	3.6	-0.1	3.1

M = Model
K-N = Krantz and Nilsson

Source: Krantz and Nilsson (1975).

During the 1870s agricultural production grew at a rate of 1.8 percent in the historical data and at 1.9 percent in the model. In the 1880s the growth rate slowed down. The model captures the tendency but not the magnitude of this change. The historical growth rate is 0.9 percent during the 1880s compared with 1.7 in the model. But the model's tendency to slow the rate of growth is more obvious when looking at shorter periods. The annual growth rate between 1880/84 and 1883/87 is 1.6 percent and between 1883/87 and 1886/90 1.1 percent. The direction of change in the model is the same as in history, but not with the same strength. The faster agricultural growth in the model also "explains" roughly half of the difference between simulated and observed GNP growth. Agricultural production amounted to around 40 percent of GNP both in the 1870s and the 1880s.

The growth of manufacturing was rather fast during the period of study. Our model generates growth figures which are rather stable for the entire period and close to observed ones (3.7 compared with 3.6). But looking at subperiods there are differences. The figures by Krantz and Nilsson are higher for the second decade than for the first decade. However, these average growth rates are heavily influenced by the phases of the business cycles. Both 1871 and 1880 were years during a downswing of a cycle, but 1890 on the other hand was a peak year. Therefore, the fast rate of growth between 1880 and 1890 in the historical records can partly be attributed to different phases of the business cycles of the starting and the terminating years.

With respect to the simulations of the other sectors reported in Table 5.2, the rates of growth in the model are higher for both services and building and construction. Building and construction is the sector that diverges most from the observed development. The growth is too fast. Demand for building and construction is mainly for investment so the figures reflect an excessive capital accumulation in the model. However, the time path of production is fairly close to the historical movements, as can be seen in Table 5.3, where average figures for subperiods are presented. The fluctuating figures in the model reflect fluctuations in investment and savings. In the model domestic savings and foreign savings add to total savings. Foreign savings are exogenously determined and display a rather fluctuating pattern during the period of study.

Table 5.3 Growth rates of value added in the building and construction sector (fixed prices, annual rates)

	Krantz and Nilsson	Model
1871/75 - 1874/78	6.5	11.0
1874/78 - 1877/81	-0.7	5.5
1877/81 - 1880/84	-3.6	-0.1
1880/84 - 1883/87	0.4	5.5
1883/87 - 1886/90	-0.3	3.3

Source: Krantz and Nilsson (1975).

The performance of the model on the sectoral level can also be evaluated by a "goodness-of-fit" test. But the result is not as good as the result for GNP growth, see Table 5.4. The results also differ considerably between sectors. The data that are used are yearly figures. Thus all short run fluctuations heavily influence the results. This is especially important for sector 4. The model generates a smooth growth path but the historical figures exhibit large fluctuations. Between 1871 and 1876, for example, an index of the yearly historical figures shows the following fluctuating pattern: 100, 117, 157, 192, 156, 173.[3]

Table 5.4 Test of the model accuracy for sectoral value-added

	$\hat{\alpha}$	s_{α}	$\hat{\beta}$	s_{β}	R^2
Sector 1	-1.40	20.59	1.09	0.19	60.3 %
2+3	-39.87	23.24	1.22	0.15	65.1 %
4	128.70	45.74	0.06	0.44	3.9 %
5	-223.84*	37.19	3.3**	0.29	26.6 %

Regression equation: $P(t) = \hat{\alpha} + \hat{\beta}A(t)$

s = standard deviation

* the hypothesis that $\hat{\alpha} = 0$ can be rejected at the 95 % level of significance

** the hypothesis that $\hat{\beta} = 1$ can be rejected at the 95 % level of significance

Industrialization

The 1870s are regarded as the outbreak of industrialization in Sweden. However, data indicate that the 1870s were just the first wave of industrialization. This period was followed by a decade of stagnation. The share of value added in manufacturing and building and construction out of GNP is one measure of industrialization. During the 1870s the share rose from 18.3 percent to 22.6 percent, a rather rapid transformation. In the 1880s it stabilized around 22 percent (see Table 5.5). The model predicts a similar pattern: a rise in the 1870s, with a peak during the first years of the 1880s, followed by a slight decline.

In the model the slowdown of industrialization is explained by a reallocation within the urban sector rather than between rural and urban sectors. All the urban sectors display a higher rate of growth than the agricultural sector. During the first decade both manufacturing and building and construction grow at a faster rate than the service sector. But during the second decade services displays the fastest rate of growth.

Table 5.5 Industrialization[1)]

	Krantz and Nilsson	Model
1871/75	0.183	0.187
1876/80	0.226	0.201
1981/85	0.220	0.220
1986/90	0.228	0.206

1) Defined as the share of value-added of manufacturing and building and construction out of GNP.

Source: Krantz and Nilsson (1975).

Exports and imports

Turning to the export and import figures, more or less the same picture emerges as when looking at sectoral growth rates. As can be seen in Table 5.6, the discrepancy between model and history in average annual growth rates is quite large in a couple of cases. Export figures seem to be somewhat closer than import figures. Agricultural export decreased rapidly in the 1880s. The model captures this development even though the turning-point comes earlier in the model than in history. There is a slight increase in the early 1870s before the steady decline starts.

Exports of the export-oriented industry (sector 2) are under-estimated in the model taken over the entire period. During the 1870s the increase is faster than in history and in the 1880s much too low. The stable growth rates that are shown in the historical records are surprising against the background that the 1870s have been seen as a decade of export-led growth in the sawmill industry and the 1880s as a decade of slowdown. The sector 2 export figures generated by the model are very fluctuating. They increase between 1880 and 1885 and then start to decline. Between 1885 and 1890 the decline is roughly 50 percent. This means that when averaged over several years, the results of the model approach historical values.

Table 5.6 Sectoral growth rates of export and import (fixed prices, annual rates)

		1871-1880	1880-1890	1871-1890
Export				
Agriculture	J	0.4	-5.9	-2.9
	M	-0.8	-6.5	-3.8
Export-oriented industry	J	3.7	3.7	3.7
	M	5.0	-0.9	1.9
Homemarket-oriented industry	J	9.0	8.3	8.6
	M	1.7	7.0	4.5
Services	J	4.0	1.0	2.4
	M	3.6	1.1	2.3
Import				
Agriculture	J	2.4	5.1	3.8
	M	-0.6	1.3	0.7
Export-oriented industry	J	4.8	8.9	7.0
	M	5.6	7.9	6.8
Homemarket-oriented industry	J	5.5	3.0	4.2
	M	5.4	-4.2	0.3

J = Johansson
M = Model

Source: Johansson (1967).

Summing up the performance of the model in this respect one can see that more than half of the predicted sectoral growth rates are fairly close to actual figures. As can also be seen, there is a tendency in the model to underestimate sectoral annual growth rates of imports and exports.

Savings and capital formation

Domestic saving in the model is generated by rural, urban and government savings. The sectoral savings are determined by the functional income distribution and exogenously determined savings ratios. These ratios are different for labor income and income from capital, with an assumption that capitalists save more than workers. It is also assumed that workers only save out of their supernumerary income. The pattern of domestic saving as a share of GNP is shown in Figure 5.3. The domestic savings ratio increased to 13 percent in the early 1880s and fell back to 12 percent toward the end of that decade. As is also seen in the diagram, the predictions of the model are completely opposite to what is reported in the historical records. During the 1870s the savings ratio fell and stabilized at a low level during the 1880s.

Figure 5.3 Domestic Saving

Source: Krantz and Nilsson (1975).

However, looking at the development of the historical share of domestic saving during the period 1890 to 1915 (see Figure 2.3 on page 23) a different pattern emerges. During the entire pre World War period there was a steady increase in the share of domestic saving. Thus the downswing in the 1880s was temporary. The model thus captures the long term trend but not the short term downswing.

There is, however, a turning-point in 1884 in the model. How can it be explained? There are several forces making up the pattern of domestic savings. Looking at rural saving, it increases during the entire period. In the beginning of the period it is roughly 20 percent of total domestic savings and toward the end of the period it increases to 28 percent. The change in income distribution decreases rural saving (see Table 5.7) but it is not enough to counterbalance the growth of savings generated by the increase in agricultural value added. The increase in rural saving is also enforced by rural-to-urban migration. In the 1880s the rural population diminishes, thus increasing supernumerary income and savings. Rural saving thus contributes to the increase in the share of domestic saving. The decline during the last 5 years is explained by the development of urban saving. However, the reason is not changes in the functional income distribution. Up to 1885 the wage share increases and after that year it decreases. But urban saving diminishes after 1885 by almost 6 percent. There are two reasons. First, urban value added decreases during the last 5 years. In 1890 it is roughly 4 percent lower than in 1885 because of reallocation between the urban sectors, from manufacturing and building and construction to services. Secondly, the large growth of urban population increases basic needs consumption. It decreases supernumerary income which is the base of savings.

Table 5.7 Development of the wage share in the model

	1871	1875	1880	1885	1890
Agriculture	52.7	52.7	52.8	53.6	55.3
Urban sectors	48.8	52.2	53.3	59.4	57.9

Even government savings contribute to the pattern of domestic savings. Until 1885 government savings grow and are then kept at almost the same level throughout the period.

Table 5.8 Capital accumulation 1871-1890 (fixed prices, annual rates)

	1871-1880		1880-1890		1871-1890	
	P	M	P	M	P	M
Rural capital stock	0.6	0.4	0.4	1.4	0.5	0.9
Urban capital stock	3.1	3.2	1.9	3.9	2.5	3.5
Total capital stock	2.0	2.0	1.4	3.0	1.7	2.5

P = Parks
M = Model

Source: Parks (1966) and Krantz and Nilsson (1975).

The higher savings predicted by the model explain quite a lot of the overestimation that was reported when looking at overall and sectoral growth rates. Too much capital is accumulated. The growth rates of the capital stocks are tabulated in Table 5.8. Between 1871 and 1890, the average rate of growth was 1.7 percent in history and 2.5 in the model. Comparing the two subperiods, the influence of the badly predicted domestic savings ratio in capital growth is clear. During the 1870s the growth of capital in the model is identical with actual figures, but during the 1880s more than twice as fast. The sectoral allocation can also be seen in Table 5.8. There is a tendency in the model to allocate a larger share of investment to the rural sector.

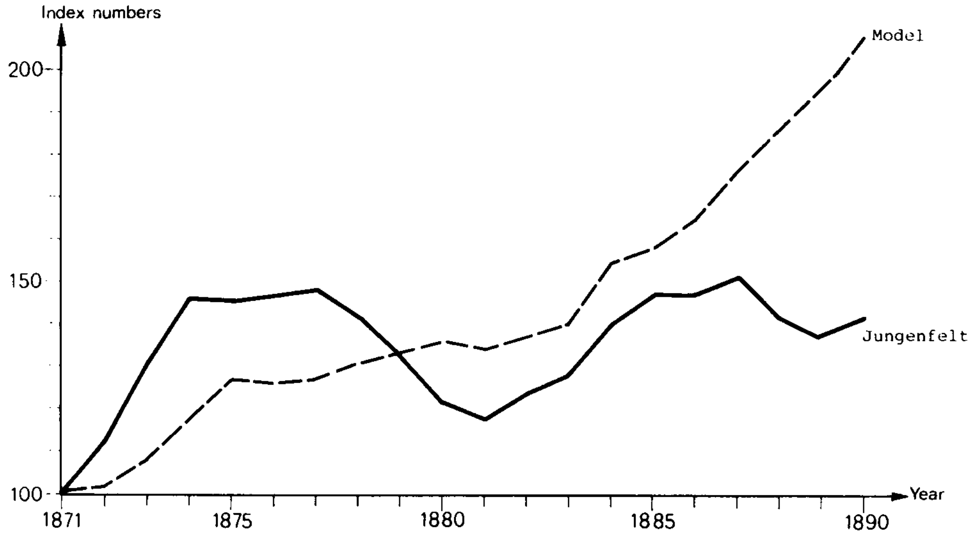
Wages and domestic prices

Another part of the economy where the model should predict changes concerns prices, both relative commodity prices and factor prices. The availability of historical data is a problem when making an evaluation. To our knowledge there exist no data on sectoral rate of return on capital. But on wages and relative commodity prices there are historical data suitable for an evaluation. Therefore we are only able to evaluate wages and commodity prices.

The wage series are shown in Figures 5.4 and 5.5. According to historical data, there was a more or less fixed relationship among wages in the urban sector during the period of study. This is built into the model, and therefore it is enough to look at just one urban wage. The historical wages are based on figures in Jungenfelt (1966) and recalculated to correspond to the model wages.

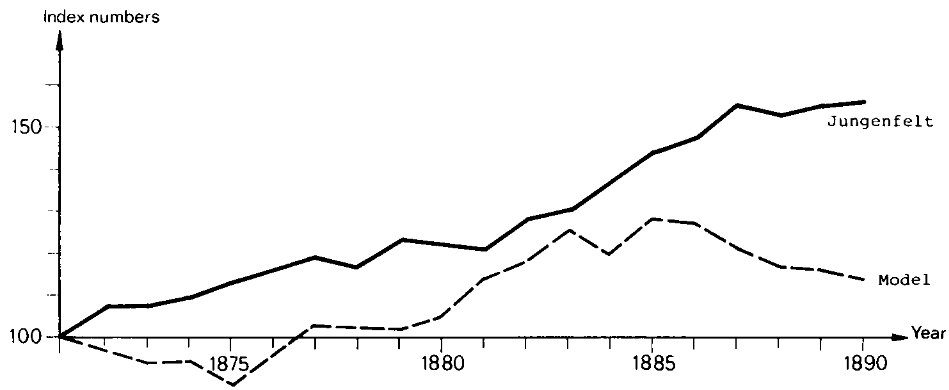
As we have pointed out earlier in this chapter, the model is not intended to capture short-run fluctuations. In the model, wages and prices are very sensitive to small changes in supply or demand. As we have seen, there is considerable discrepancy between model predictions and actual data. Thus we can hardly expect good accuracy in this respect. The general trend in rural and urban wages is captured by the model. Looking at rural wages we can also see that parts of the variation during the period are reflected in the predictions of the model; the increase in the early 1870s, the stagnation during the middle part of the period and the upswing in the early 1880s. However, the model misses the fall in agricultural wage during the final three years. The impression that the model describes a qualitatively different development path at the end of the period should, however, be moderated. If we extend the historical figures beyond 1890 we will find a rapid increase in agricultural wage. The decrease at the end of 1880 is only temporary. The same tendencies emerge from other historical wage series. The real wage for agricultural workers assembled by Jörberg (1972b) and displayed in Chapter 2, p. 19, shows the same tendency, a trough at the end of the 1880s followed by a rapid increase. The increase in percent between 1870/74 and 1910/13 is 102 percent. Thus the model captures the increasing trend in agricultural wage, even though it is somewhat too fast, but it does not predict the temporary downward movement in the 1880s.

Figure 5.4 Real Wage in Agriculture



Source: Jungenfelt (1966)

Figure 5.5 Real Wage in the Urban Sector



Source: Jungenfelt (1966)

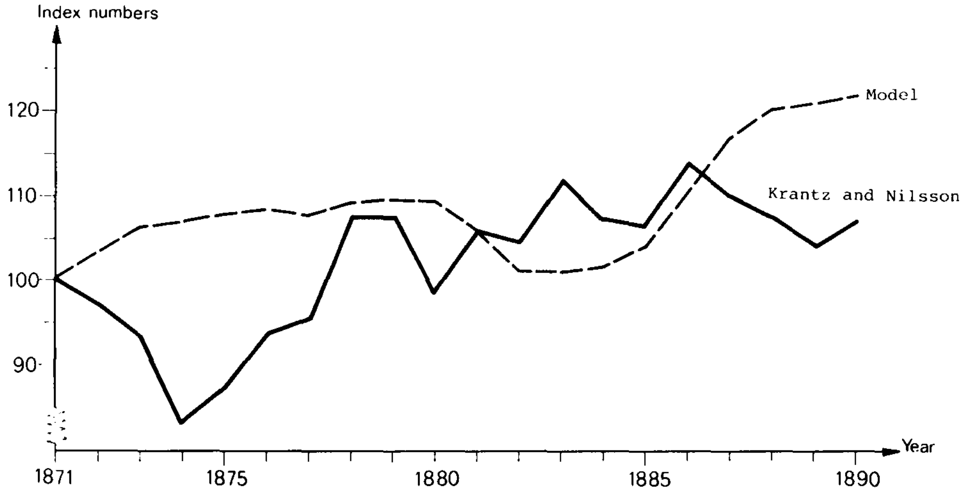
The urban wage also differs somewhat from the reported figures. In the model it falls during the first four years, which is not reported in the historical figures. But from the middle of the 1870s to the middle of the 1880s, the prediction is fairly close to the historical trend.

Krantz and Nilsson (1975) have published price series for sub-sectors. We have used these series to construct relative price series that correspond to the aggregation of commodities used in the model. All prices are thus relative to the price in sector 2 that is used as a numeraire in the model. The historical series of relative prices exhibit very few clear tendencies (see Figures 5.6-5.9). One is that the prices of sectors 3 and 4 decrease relative to the price of sector 2 during the 1870s, and increase relative to that price during the 1880s. These changes in sector 3 are not captured by the model. But in sector 4 the model predicts a pattern close to historical figures during most of the period. The model predicts an increase in the price of agricultural goods during the 1880s (see Figure 5.6), but there is no correspondence in historical figures. In sector 5, predicted and actual relative prices are rather close.

Figure 5.6 Relative Price in Agriculture

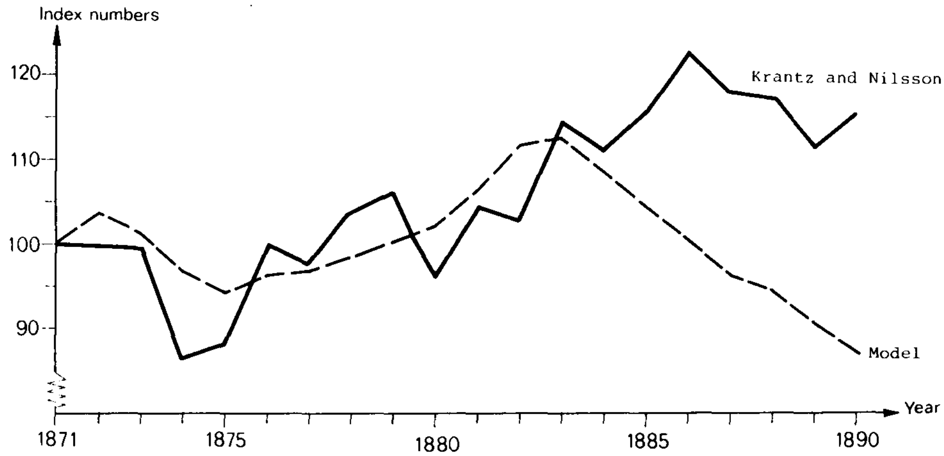
Source: Krantz and Nilsson (1975)

Figure 5.7 Relative Price in Sector 3



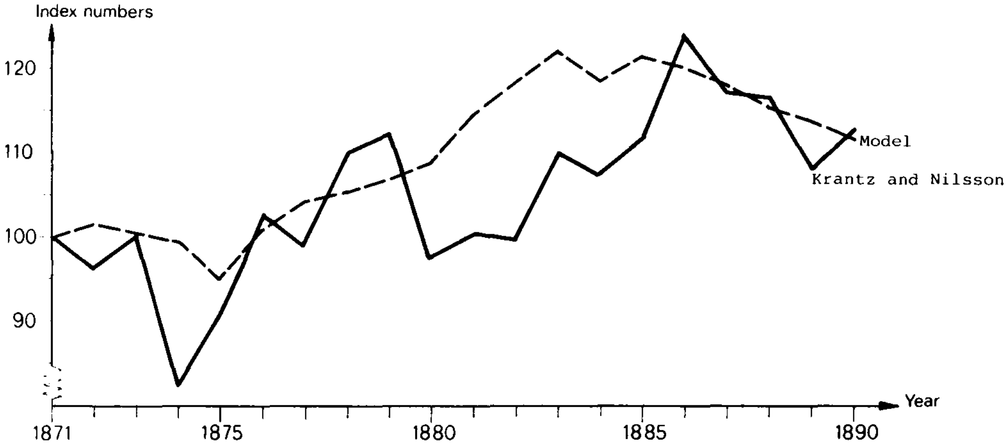
Source: Krantz and Nilsson (1975).

Figure 5.8 Relative Price in Sector 4



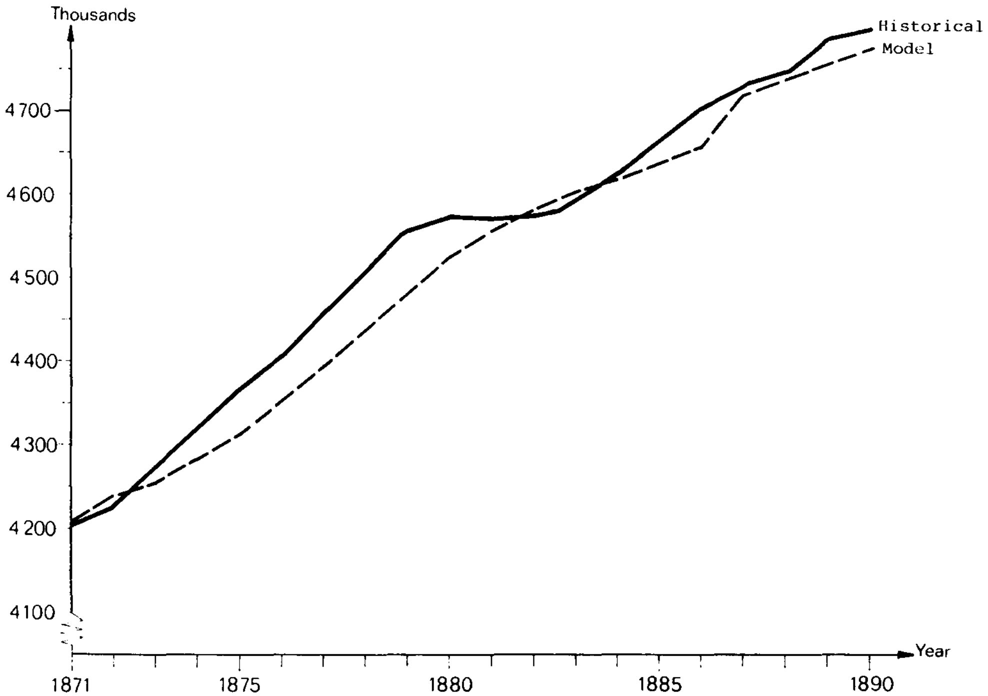
Source: Krantz and Nilsson (1975).

Figure 5.9 Relative Price in Sector 5



Source: Krantz and Nilsson (1975).

Figure 5.10 Total Population 1871-1890 (thousands)



Source: Historical Statistics of Sweden (1969).

The question is how well observed relative prices should be predicted by a computable general equilibrium model. The model should not be able to capture short run fluctuations. On the other hand, trends in relative prices reflect structural changes in the economy. A good model should capture such changes. As we have seen in the previous sections, the differences between the historical figures and the base run simulation are enlarged towards the end of the period. They are also reflected in the relative price changes.

Population and migration

The model distinguishes between population and labor force. The labor participation rates are exogenous and full employment is always assumed. Changes in urban and rural population thus have an impact on the development of employment in rural and urban regions. Through the incorporation of a migration function between rural and urban labor markets, the demand for labor will also influence employment. Natural increase in population, emigration and rural-to-urban migration "determine" employment.

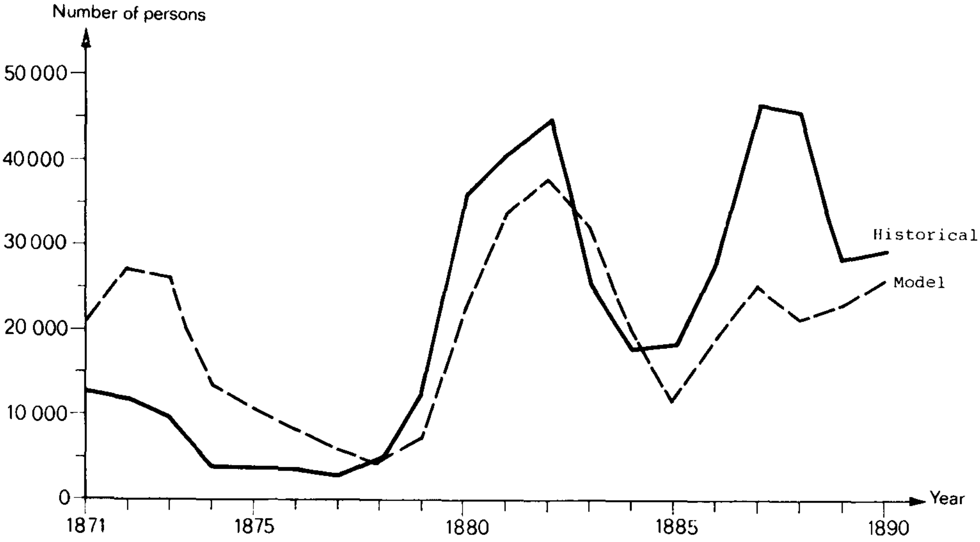
Natural increase of population is exogenous but different between rural and urban regions. The model does not try to explain the changes in natural increase, lacking a generally acceptable theory of demographics. Population growth is also determined by emigration which is endogenous. Thus total population is endogenous. The fit between historical pattern and prediction by the model is very good. Total population is shown in Fig. 5.10 and natural increase of population in Figs. 5.11 and 5.12. As can be seen in Figure 5.11, emigration is as important as natural increase in determining total population growth during this period. Emigration exhibits a rather fluctuating pattern (see Figure 5.13). The model predicts this pattern remarkably well.

Figure 5.11 Changes in Population 1871-1890, historical figures

Source: Historical statistics of Sweden (1969).

Figure 5.12 Changes in Population 1871-1890, model simulation

Figure 5.13 Emigration 1871-1890



Source: Runblom and Norman (1976).

The accuracy of the model predicting emigration can also be evaluated by using the turning-point test discussed in the beginning of this chapter. The model predicts 5 turning-points (which also occurred), does not miss any but generates one which is not reported in the historical data. Predicting emigration, the model generates a result which is surprisingly good.

The performance of the model with respect to rural-to-urban migration is impossible to evaluate. There are no yearly statistics available either on migration or on agricultural employment. The existing employment figures for agriculture are interpolations between the years of censuses, so it is impossible to evaluate the migration pattern using these figures. The only basis for comparison is statistics from the Population Censuses each 10th year. However, comparing the distribution of population 1880 and 1890 predicted by the model with the historical data may suggest how close the amount of migration over a decade is to what actually happened. In both 1880 and 1890 the distribution is very close between historical records and the model simulation. Between 1871 and 1890, urban population grew at an annual average of 2.4 percent according to the historical statistics, compared with 2.7 percent in the model (see Table 5.9). During the first decade growth rates are exactly the same, but diverge during the 1880s. The rural population growth is almost the same during the 1870s. During the 1880s outmigration overtook the net increase of population in rural areas and population started to decline. The model predicts this pattern and the observed and simulated growth rates are thus close to each other even during the 1880s.

Table 5.9 Population growth (annual growth rate)

	Total population		Urban population		Rural population	
	H[1)]	M	H	M	H	M
1871-1890	0.7	0.7	2.4	2.7	-0.1	-0.2
1871-1880	0.9	0.8	2.6	2.6	0.2	0.1
1880-1890	0.5	0.7	2.1	2.7	-0.4	-0.5

1) The historical figures are taken from Historical Statistics of Sweden (1969).

Because the labor participation rates are region-specific and exogenous in the model, employment in the two regions is almost as close as population.

Table 5.10 Employment growth (annual growth rate)

	Total employment		Urban employment		Rural employment	
	J	M	J	M	J	M
1871-1890	0.6	0.7	1.6	1.9	0.1	-0.02
1871-1880	1.1	1.0	2.5	2.4	0.4	0.2
1880-1890	0.2	0.4	0.8	1.4	-0.2	-0.3

J = Jungenfelt
M = Model

Source: Jungenfelt (1959)

Employment figures for agricultural and nonagricultural activities are not available on a yearly basis. Nevertheless, for the years of population censuses, 1870, 1880, 1890, employment data are available (see Table 5.10). Existing employment statistics for the intermediate years are interpolations between the years of censuses (Jungenfelt 1959). Even though industrialization was rapid during the 1870s, employment in agriculture grew, while in the 1880s it started to decline. However, until 1890 employment in agriculture was still larger than in the beginning of the 1870s. The model predicts a faster decline (see Figure 5.14). The difference in 1890 between the historical and the simulated figures is less than 1.5 percent. It is also remarkable that the model predicts the turning-point of employment in agriculture.

Figure 5.14 Employment in agriculture

Source: Jungenfelt (1959).

Migration in the model is of course a sectoral migration, but it is important to note that it also implies a spatial migration. This geographical movement not only includes migration from rural areas to cities but also migration to rural locations which later on became towns. Urbanization defined as the growth rate of the share of urban population increases from 1.7 percent (1871-1880) to 2.1 percent (1880-1890) in the base run simulation. There exist no corresponding historical figures for the period of study. But William-Olsson (1938) has estimated the urban population using a definition which seems to be close to the concept used in this study for a later period. Very small (less than 1000 people) densely populated areas are included in his concept of urban population. Between 1880 and 1900 the estimates of William-Olsson imply an annual growth rate of 2.5 percent.

5.3 CONCLUSION

In the previous sections we have tried to evaluate the performance of the model. As was expected, the model predicts growth rates of different variables much better than the yearly figures. Short run fluctuations are not reflected in the model simulation. The model is designed to capture the long run growth pattern. In this respect its predictions are quite close, even though there are discrepancies.

We regard this study as a first attempt to apply a simple dynamic CGE model to the process of structural change and migration during the industrialization of Sweden. Although the model still needs to be refined the simulation results are encouraging. The model replicates key quantitative trends in the development. Aggregated production as well as sectoral production correspond to historical figures. The demographic variables, total and regional population, and internal and external migration, are very close to reported observations. Even though the movements of rural and urban wages become less close to the historical observations they reflect the underlying trend. However, there is one case of poor performance in the model: the development of the share of savings. The model generates a growing share. However, the prediction of the model corresponds to the trend during the entire pre First World War period. This weakness explains the tendency in the model to generate a higher growth rate of GNP than observed. This part of the model should be revised to get a better performance. However, this weakness will not alter our judgment of the model's plausability. The model is able to replicate the development - well enough, at least, to make us confident to discuss some historical problems by making counterfactual simulations.

NOTES

1) Williamson (1974), for example, has a thorough discussion of the performance of the model he uses to analyze the late nineteenth century American development.

2) The index of Swedish business cycles of this period is a series representing real investment in durable mechanical equipment for manufacturing and mining. See Thomas (194 :190).

3) One can question such fluctuating figures. Does a 22 percent increase between 1873 and 1874, and a 19 percent decrease between 1874 and 1875 reflect what actually happened, or are there some errors in the data?

6. Counterfactual Histories

6.1 INTRODUCTION

Our approximation of the Swedish development 1871-1890 was discussed in the previous chapter. The fit was hardly perfect but sufficiently close in our judgement to warrant use of the model in historical analysis. In this chapter we will discuss some of the crucial factors in the early industrialization process by simulating counterfactual histories. These simulations are compared with our base run.

Discrepancies can be directly attributed to the change in a certain parameter or exogenous variable. Such an experiment makes it possible to quantify how much a specific variable contributed to the Swedish development during the period of study. Our experiments are of two kinds. One kind of experiment evaluates effects at one point in time. The other kind evaluates effects over time. As we will see, the effects are considerably dampened when the dynamic aspect is taken into account. Two different issues will be discussed in this chapter; the agricultural development and the role of emigration. The model used in this chapter is the complete non-linear model discussed in Chapters 3 and 5.

In the next section we focus on agricultural development. Experiments are undertaken which evaluate the importance of such variables as productivity, reclamation of land, labor supply and the fall in grain prices on the world market.

Emigration has been identified as a strategic variable in the late 19th century development. In the last section we simulate counterfactual histories without any emigration.

6.2 DEVELOPMENT OF SWEDISH AGRICULTURE

A depression in Swedish agriculture?

One of the largest political issues during the second part of the 19th century was the protectionist policies shielding agriculture which were introduced in the late 1880s. The main argument for a new direction in trade policy was the "depression" in agriculture. Falling grain prices and high emigration were regarded as indications of a deep crisis in Swedish agriculture. This general picture of the 1880s has prevailed since then. The opinion is further emphasized by Svensson (1965) who critically examined the agricultural statistics of the 1870s and 1880s. He concludes that figures on land acreage and agricultural production were too low in 1870 and thus the growth rate was too high during the 1880s in the early statistical records. Based on this result, Svensson argues that Swedish agriculture suffered a setback in the 1880s that completely interrupted the previous positive development. Carlsson (1980) has a similar opinion. In the 1880s there was a reduction in Swedish grain exports because of falling world market prices. Carlsson argues that the industrial sector was too small to absorb the surplus labor. The result was a huge wave of emigration. Without the grain exports during 1850-80, Carlsson argues that the wave of emigration would have started earlier.

Jörberg (1967) mentions several facts that should be considered before concluding that there was a deep crisis in Swedish agriculture in the 1880s. First, the falling price of grain was not unique. Other prices fell even more. This fact is displayed in different price series. The figures presented in Chapter 5 indicate a slight increase in the terms-of-trade of agriculture during the 1870s and 1880s despite some fluctuations, see Figure 5.6 on p. 115.

Jörberg (1967) calculates the price of agricultural goods relative to the price of industrial raw material as well as compared with the price of refined industrial goods. In both cases there was an improvement in the terms-of-trade of agriculture. There was an improvement of almost 50 percent between 1871/75 and 1896/1900 in the price of agricultural goods relative to refined industrial goods.

A second factor which casts some doubts on the agricultural depression is the movement of agricultural wage. As was discussed in Chapters 2 and 5, the real wage rose in spite of fluctuations during the second part of the 19th century. Jörberg (1972b:344) has calculated the following averages for day-workers' real wage for the period:[1]

1845/64	89	1875/94	121
1855/74	97	1885/04	142
1865/84	106	1895/14	165

1860/64 = 100

Nevertheless, one has also to consider some other striking facts which complicate the picture. Population grew during the entire period, but in the early 1880s the agricultural labor force started to decline in absolute terms. Despite Svensson's results, cultivated land increased to some degree during the period 1870--1890. Simultaneously one can also observe an increase in agricultural productivity.

Against this background it is difficult to argue that there was a deep crisis in the agricultural sector. In terms of the development of real wage there was not. But it is not clear what is really meant by the concept "agricultural crisis". The agricultural development was very complex. Many farms were seriously hit by increasing costs and decreasing world market price on grain, Heckscher (1957). In those cases there was a cost crisis which caused a transition from grain production to production of animals. But in this study we do not analyze the transformation within agriculture. Instead we focus on agricultural development on a more aggregated level and especially discuss the movement of relative prices and agricultural real wage.

The counterfactual simulations

Which were the fundamental driving forces behind the agricultural development in the 1870s and 1880s? This question will be analyzed in a couple of counterfactual simulations.

The agricultural sector cannot be analyzed in isolation. The development of the rest of the economy had a significant influence on its development. Demand from the growing industrial sectors affected the price of both agricultural goods and factors of production, thus highly influencing agricultural development. These factors have to be incorporated in an analysis of the agricultural sector. We will use our non-linear CGE model for counterfactual experiments in order to shed some light (or at least provoke questions) on the mechanisms behind the development of agriculture.

The counterfactual simulations undertaken in this section are both static and dynamic. The static counterfactual simulations focus on the importance of some of the factors previously discussed. The variables we will look upon in the static simulations are population, productivity and arable land. Their effects reach beyond the rural sector. Via the commodity markets they influence commodity as well as factor prices in the urban sector. However, in an economy with an integrated factor market price changes initiate a reallocation process of factors of production. A redistribution will influence the speed of growth. Incomes and savings rise and thereby investment and capital formation. The effects of a change in a variable in agriculture reach far beyond the rural sector and the time when the initial change occurred. Thus, we need also to analyze the dynamic effects of these variables.

In the following section we try to evaluate all these effects by simulations in three stages. It is difficult to draw general conclusions from these simulations. As was discussed in Chapter 4 the non-linearities are quite important in the model. Thus, the result of a change in an exogenous variable depends on the size of the change. Therefore the conclusions we draw from these simulations should be interpreted carefully.

In the first stage we use our static model. In the static model there is a "semi-integration" between the rural and the urban sectors. It is illustrated in Fig. 6.1 (a). On the commodity side there is a complete integration between the urban and the rural sector. But on the factor side no redistribution between the two regions takes place. In the first stage of analysis the following four counterfactual simulations are undertaken:

Counterfactual No. I: Increase in rural population by 6.92 percent.

Counterfactual No. II: In addition to the previous experiments arable land is increased by 10 percent.

Counterfactual No. III: Rural population (+ 6.92 %) and labor productivity in agriculture are increased by (10 %).

Counterfactual No. IV: Rural population, arable land and labor productivity are increased at the same time.

In these four simulations we capture the initiating effect on agriculture, but also the general equilibrium effects via the integrated commodity markets.

In the second stage of analysis the effects of migration of labor from rural to urban regions are captured. However, there is no complete integration of the factor markets because we will still use the static model. Half of the increase in rural population analyzed in simulation No. I is in this simulation allocated to the urban region. Thus, both rural and urban population increases.

Counterfactual No. V: Increase in rural population by 3.5 percent and in urban population by 9.1 percent.

In the last stage redistribution via the factor markets is incorporated into the analysis, See Fig. 6.1 (b). We use the dynamic model. Beside the integration of markets also dynamic variables such as productivity growth, capital formation and growth of the world market play a role. They influence both rural and urban regions. This simulation thus captures the effect of the agricultural variables within an integrated and expanding economy.

In the last counterfactual simulation of this section we use the dynamic model to analyze the importance of the fall in grain prices on the world market. It is also a factor which much attention has been paid to when discussing the Swedish development in the late 19th century.

Figure 6.1 (a) Interaction between sectors and markets in the Static Model

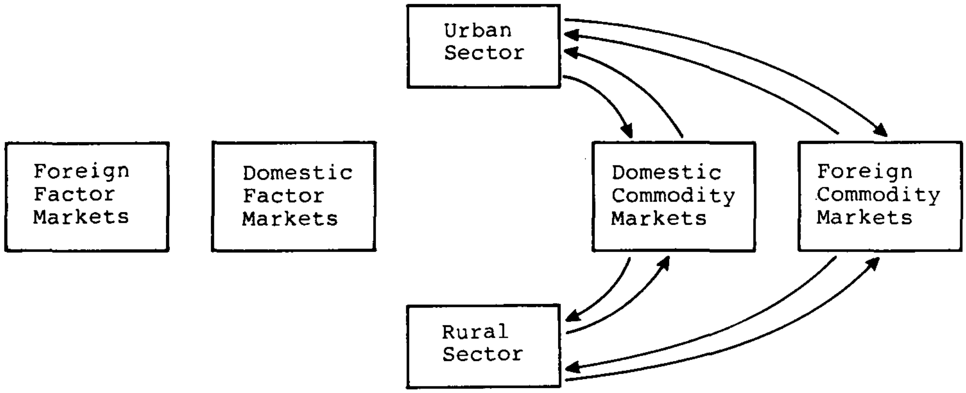
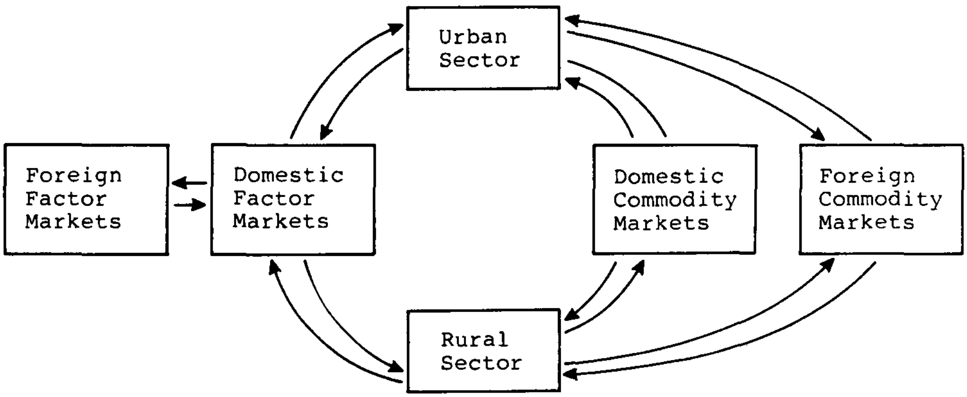


Figure 6.1 (b) Interaction between sectors and markets in the Dynamic Model



Counterfactual I: Increase in rural population

The growth of population was one of the most fundamental factors in the development of Sweden. Therefore we will once again look at the results of a 5 percent increase in total population. It is assumed that the entire change occurs within the rural area. Urban population is thus constant. This is of course an extreme assumption, but the experiment is undertaken to isolate the effect on agriculture. Rural population increases in this case by 6.9 percent. This is approximately the actual natural increase (births minus deaths) during 5 years in the 1870s or 1880s. The rates of natural increase per 1000 population were 12.9 and 12.3, respectively, in the rural region (see Table 2.4 p.32). This experiment is thus a case with a population shock in the rural region with no possibilities for migration.

Some of the results are displayed in Table 6.1 and Appendix C, Table C.1. Agricultural output increases by 4.8 percent. But this increase is not simply added to the previous supply on the domestic market. Export increases (by 15 percent) and import decreases (by 0.2 percent). The domestic price must fall (by 5 percent) to restore equilibrium. Increased demand by rural (by 4.9 percent) and urban (by 4.9 percent) households and demand for intermediate deliveries are not enough to match the increased supply.

The large change in population has a strong effect on the agricultural wage rate which falls by 9.9 percent. The increase in the labor force, with fixed land and capital stock, diminishes the marginal productivity of labor. This downward pressure on the wage rate is strengthened by a decrease in commodity prices.

The relative price of agricultural goods declines, but it is not the only commodity price affecting the rural wage. The relative prices of urban goods influence costs in agriculture as well, since urban goods are inputs in agricultural production. It is the net changes in value-added prices (P_i^*) that are relevant for analyzing how changes in commodity markets affect factor returns.

$$P_i^* = P_i - \sum_{j=1}^{5} P_j^D a_{ji}$$

Thus, both direct price effects on sector output and price changes in intermediate goods are of interest. In this experiment the price changes for urban goods increase the cost of intermediate goods used in agriculture and further reduce the rural wage.

Table 6.1. Counterfactuals I-IV. Percent change compared with the base solution.

	I	II	III	IV
	N_A+6.9%	N_A+6.9% R_1+10%	N_A+6.9% h_1+10%	N_A+6.9% R_1+10% h_1+10%
Production in agriculture	4.8	6.8	11.9	14.1
Domestic production cost in agriculture	-5.4	-8.7	-16.0	-18.6
Wage in agriculture	-9.9	-12.7	-19.6	-21.9
Rate of return on capital in agricult.	-6.8	-9.7	-14.9	-22.9
Export of agr. goods	15.0	25.6	54.5	67.3
Import of agr. goods	-0.2	-1.5	-4.5	-5.6
Rate of return on capital in the urban sector	2.8	4.5	8.4	9.9
Wage in the urban sector	2.6	4.2	7.5	8.7
Agricultural savings	-6.5	-9.3	-15.4	-17.8
Urban savings	4.8	7.8	14.6	17.2
Investment	-0.5	-0.9	-1.5	-1.8
GNP	1.3	1.6	2.4	2.7
GNP per capita	-3.6	-3.4	-2.6	-2.3
Migration pressure*	6.0	19.4	33.8	39.4
Emigration	13.1	15.8	21.9	24.0

* Migration pressure is simply an index of the relationship between wages in urban and rural regions (W_U/W_1) set to 1 in the base run.

In our first counterfactual experiment the increased rural population has the opposite effect on the urban wage compared with the rural wage. It increases by 2.6 percent. This is the result of the reallocation of labor among the urban sectors, which is caused by price and income changes. Thus, the development in the rural as well as the urban regions has the same strengthening effect on rural-to-urban migration. Relative wage differentials are increased by almost 13 percent. The fall in disposable income in the rural region decreases rural saving. Together with lower government saving, the decrease is larger than the increased saving by urban households. Total saving and investment diminish with almost 0.5 percent.

The total increase in GNP is 1.3 percent, but this increase is not enough to balance the growth in population. Per capita income decreases by 3.6 percent.

The conclusion of this experiment is that a population increase, ceteris paribus, has a tremendous pauperizing effect on agriculture. The lower marginal productivity of labor is not the only negative consequence. It is reinforced by the price effect. The growth in demand caused by a larger population is not enough to balance increased supply and the terms of trade between agriculture and industry deteriorate. The consequences for the growth of the economy are unclear. It is true that the growth of capital slows, but the pressure to redistribute labor to sectors with higher productivity increases.

Counterfactual II: Increase in rural population and reclamation of land

The Swedish experience of the 1870s and 1880s was characterized by population growth accompanied by an increase in productivity and reclamation of land. How much are the previous results changed by these effects? Did these two factors offset the pauperizing effect of population growth? To answer these questions we will look at the next two static counterfactual experiments. In our second counterfactual simulation the acreage of land is increased by 10 percent in addition to the previous increase in population. In the third one the labor force productivity is changed in addition to the population increase: labor-augmenting technical growth is increased by 10 percent. Results are displayed in Table 6.1.

The immediate effect of a simultaneous expansion in cultivated land and rural population is an increase in agricultural production by almost 7 percent. The increase in land acreage adds 2 percent to the effect of a larger population. Demand for agricultural goods is both price and income-inelastic. Private demand does not change enough to absorb the increased output without significant price cuts. But the surplus of agricultural goods could be exported. That is also what occurs. Exports increase and imports decrease resulting in a large export surplus of agricultural goods. However, the net effect on the domestic market is a substantial decrease in agricultural price. Neither the world market demand nor the domestic demand is large enough to support the previous price.

Turning to factor returns in agriculture, we could expect an increase in the wage rate because the marginal productivity of labor rises with land acreage, ceteris paribus. However, commodity price changes could reverse the effect, as they do in this case. The rural wage diminishes by almost 13 percent. This represents a further decrease of 3 percent compared to the effect of larger rural population alone. The price changes have a stronger effect on the rural wage than the increase in productivity.

The value-added price in agriculture falls. As we can see in Table 6.1, return on capital in agriculture also diminishes in this experiment.

Counterfactual III: Increase in rural population and labor productivity

An increase in labor productivity in agriculture (see Table 6.1) does not solve the problem in agriculture either. Agricultural production increases by almost 12 percent in this case. Private demand grows both in rural and urban regions and net exports increase as well. The agricultural export surplus is more than 15 times larger than the base solution. Even so, the domestic price has to decrease by almost 15 percent to equilibrate the agricultural commodity market. Even in this case marginal productivity of labor increases in agriculture. As in the previous experiment, it is not enough to balance the price effects. The agricultural wage diminishes by almost 20 percent.

The rural terms of trade deteriorate in all these experiments with exogenous changes only within agriculture. Real urban income expressed in terms of food grows and a larger proportion can be used for consumption of urban goods. The growth in urban demand together with increased agricultural demand for urban inputs forces relative urban prices up. Given a constant stock of urban labor and capital, resources must be reallocated in order to meet the new pattern of demand. In all three cases the pattern of change is the same. Only the magnitude differs. Production of sectors 3 and 4 increases and decreases in sectors 2 and 5.

Urban households are gainers from all these changes in agriculture. Urban factor prices increase as a consequence of every exogenous change in agriculture, thus widening the gap between rural and urban households. The larger wage gap between the two regions increases migration pressure.

Counterfactual IV: Increase in rural population, land and labor productivity

One can conclude that the changes within agriculture during the 1880s - a larger population, reclamation of land and productivity increase - all appear to contribute to an agricultural crisis in terms of the agricultural wage. In the last column of Table 6.1 all the three exogenous changes occur simultaneously. The effect on the rural wage is devastating. It falls by 21.9 percent. All these experiments incorporate interactions with the urban sector and the world market. We observe a larger supply of commodities to both of these markets. However, the interaction among the markets does not alter the likelihood of substantial losses for rural workers. Thus, the conclusion is that the "ameliorating" factors that Jörberg emphasizes - reclamation of land, productivity increases and export possibilities - actually aggravate the agricultural crisis.

We have not yet explained the increase in the rural wage during the early phase of industrialization. Several possible explanations have just been excluded. There must have been something else happening in the Swedish economy. Two major elements are excluded in the previous analysis. In the first place the analysis is static. We have examined the effects of an exogenous shock without considering indirect effects on the growth process. Secondly, the changes in Swedish agriculture during the late 19th century were accompanied by simultaneous development of the industrial sectors. The development of agriculture cannot be understood without incorporating the factors driving the growth of industries.

The growth creating effects might be important. When looking at the counterfactual simulations I-IV investment's share of GNP declines, which tends to reduce growth rates. On the other hand, relative factor price changes favor the urban sector. Thus, we can expect a reallocation of both capital and labor from rural to urban regions. Such a reallocation might increase the growth of the urban economy and lower agricultural production.

Counterfactual V: Increase in rural and urban population

The importance of the reallocation of factors of production between the regions is illustrated in the next experiment, even though it is static. In this case the 5 percent increase in total population is allocated equally to the two regions. Rural growth of population is therefore 3.5 percent and urban growth is 9.1 percent. Some consequences are displayed in Table 6.2 (see also Appendix C, Table C.1). Agricultural output grows by 2.4 percent. Exports decrease and imports increase thus further increasing domestic supply of agricultural commodities. But now domestic demand increases more than supply and the new equilibrating price is 2.6 percent higher than the base run solution. There is also an increase in urban demand for intermediate goods produced in agriculture. The larger urban labor force increases capacity and output grows in almost every urban sector with the strongest effect in sector 2. The effects on factor returns are completely different from the previous experiments. In the rural region the price effect is stronger than the decrease in the marginal productivity of labor. Both the wage and the return on capital also rise.

Table 6.2 Counterfactual V: Increase in rural and urban population
Change in percent*

Rural population	3.5
Urban population	9.1
Total population	5.0
Production in agriculture	2.4
Domestic production cost in agriculture	2.9
Wage in agriculture	1.4
Rate of return on capital in agriculture	3.2
Export of agricultural goods	-6.9
Imports of agricultural goods	5.4
Rate of return on capital in the urban sector	10.4
Wage in the urban sector	-6.0
Agricultural savings	4.6
Urban savings	6.0
Investment	9.3
GNP	5.4
GNP per capita	0.4

* The result is relative to the base solution.

In the urban sector return on capital increases. Capital now becomes relatively more scarce. Urban wage falls by 6.0 percent. The new factor incomes and their allocation have a positive effect on both rural and urban savings. Investment increases by 9.3 percent.

This experiment indicates the importance of the two missing aspects in the previous comparative static experiments. Reallocation of factors of production between the two regions does have very significant effects on factor returns as well as on savings and capital formation. Capacity growth in the urban sector facilitates industrialization. The world market absorbs increased Swedish supply of industrial goods. Exports and production in the export-oriented sector grow most. It is thus the interplay between the industrial and the agricultural sectors of the economy that can explain the observed development of agriculture.

Nevertheless these interactions should be analyzed in a dynamic simulation. Therefore we will now look at the dynamic base simulation discussed in Chapter 5 and see what insights about agricultural development can be obtained from this simulation.

Dynamic simulation: The base run

When simulating the model over the period of study there were some changes of great importance for the urban sectors. First of all, demand increased in the world market for urban goods. Secondly, industrial capacity increased because of technical progress, capital formation and a larger urban population. Agricultural productivity was affected by the increase in land acreage and capital stock. With an increase in factors of production, output grew by 18.7 percent between 1880 and 1890 (see Table 6.3). In the rural experiments we concluded that agricultural price and rural wage fell when rural population, productivity of labor and acreage of land increased, ceteris paribus. An underlying mechanism in the dynamic simulation is thus the pressure to migrate from rural to urban regions. This is also observed in the dynamic simulation.

Outmigration from agriculture is of such a magnitude that rural population diminishes in absolute terms. The movement is caused not only by the agricultural push, but also by the pull from the urban sectors. All exogenous factors that increase capacity of the urban sectors also have a positive effect on the rural wage (see Table 4.1). The allocation of capital also favors the urban region. Savings increase both in rural (+ 83 percent) and urban (+ 17.7 percent) regions. However, the capital stock in the urban region grows the faster. There is a large rise in the rural wage (+ 62.7 percent) and a smaller increase in the urban wage (+ 15.6 percent). The relative wage differential decreases, and rural-to-urban migration diminishes. Industrialization thus created a large demand for labor that pushed the rural wage up. The upward pressure is strengthened by the urban demand for agricultural goods that increases the domestic price by about 23 percent. The indirect effects via the commodity market is thus of great importance for explaining the increase in rural wage during the period of study.

<u>Dynamic counterfactual simulation: Constant grain prices on the world market</u>

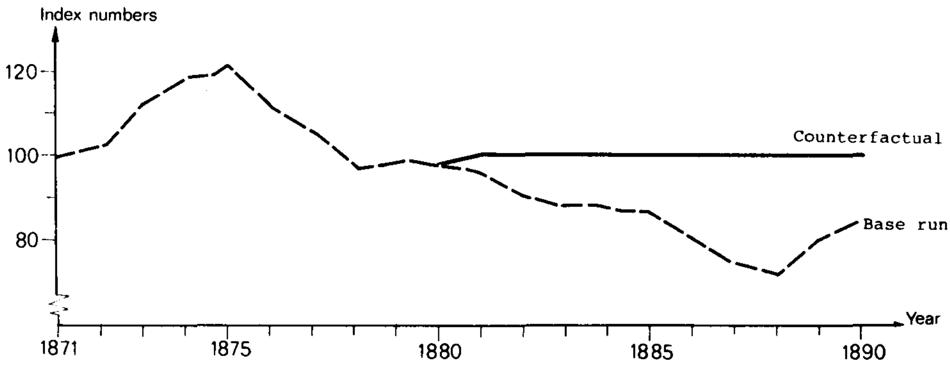
The fall in the price of grain on the world market has been regarded as a crucial factor when analyzing the Swedish development of the 1880s. To estimate its consequences we undertake a dynamic counterfactual simulation with a higher world-market price (P_1^W) than is used in the base run. In this simulation the world-market price for agriculture is kept at the approximate level of 1880 during the 1880s. All other exogenous factors are kept the same when simulating a new development path between 1880 and 1890. The new price is displayed in Figure 6.2. Some of the results are shown in Table 6.3 and

Figures 6.2-6.5. The decline in agricultural exports is completely offset, staying constant at the 1880 level. The larger exports have a positive effect on agriculture but a negative on the economy as a whole. The domestic price of agricultural goods rises as well as the rural wage. The process of urbanization slows down. Emigration to the United States diminishes. Rural population decreases, but only by 2.9 percent in 1890. Agricultural production increases more than in the base run. The total effect on the economy of a higher world market price is lower growth in per-capita GNP. Thus, the external shock of the price fall does not change the general development pattern of agriculture or for the whole economy. There are of course negative effects on the rural sector, but the impact is not of sufficient magnitude to justify characterizing it as an "agricultural crisis".

Table 6.3 Base simulation and counterfactual simulation 1880--1890. Change in percent between 1880 and 1890.

	Base simulation	Higher world market price for agricultural goods
Production in agriculture	18.7	20.4
Production in export-oriented industries	28.8	16.3
Production in homemarket oriented industries	66.2	64.0
Production in services	43.0	44.0
Production in building and construction	36.2	38.6
Rural population	-4.7	-2.9
Urban population	31.6	29.0
Capital stock in agricult.	15.0	16.9
Urban capital stock	47.6	49.4
Domestic prices of commodity 1	23.2	26.5
Wage in agriculture	62.7	64.8
Rate of return on capital in agriculture	40.4	42.4
Export of agricult. goods	-35.7	-8.3
Import of agricult. goods	48.1	33.4
Urban wage	15.6	13.0
Urban rate of return on capital	-26.0	-30.7
Agricultural savings	83.0	87.9
Urban savings	17.7	10.2
Investment	75.8	74.8
GNP	38.5	38.2
GNP per capita	31.6	30.8

Figure 6.2 World market prices.



Counterfactual simulation: Constant grain prices on the world market.

Figure 6.3 Export of agricultural goods.

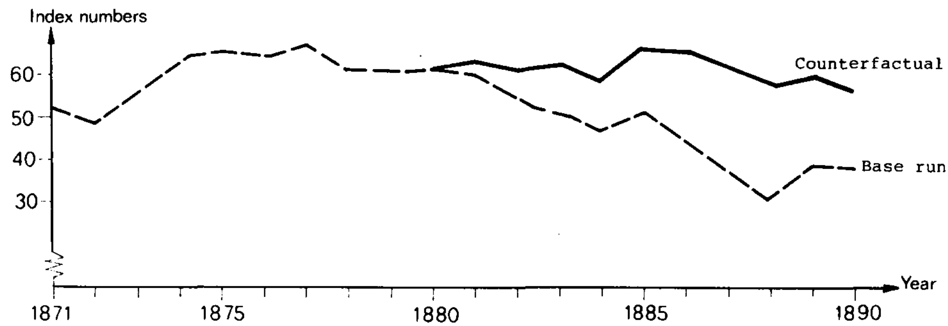


Figure 6.4 Rural-to-urban migration.

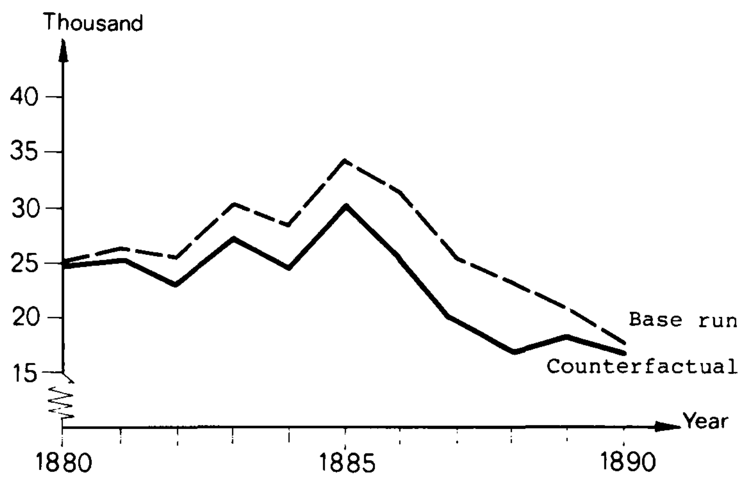
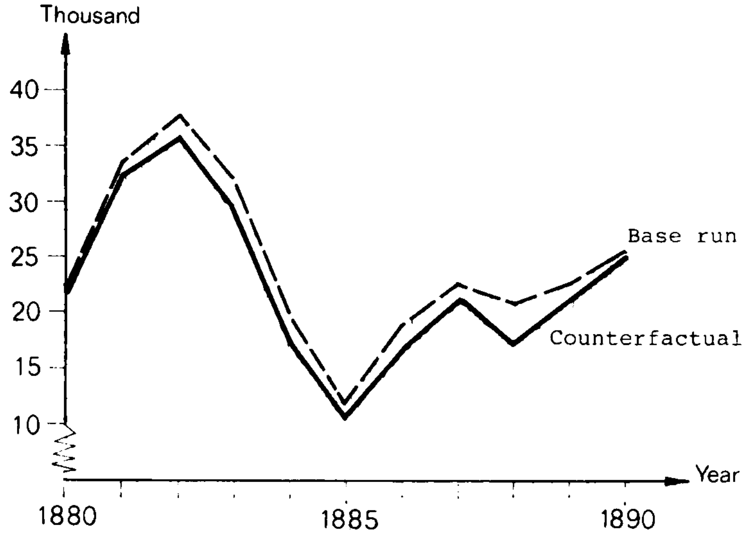


Figure 6.5 Emigration



Conclusions

In these counterfactual simulations we have tried to incorporate all those factors which seem to be important in an analysis of agricultural development during the period of study. Not only factors specific to agriculture such as productivity growth, increase in population and capital as well as reclamation of land are captured, but also links to other domestic and international markets are taken into consideration. What are the lessons?

1. Increasing labor productivity in agriculture lowered the rural wage because of the price effect. Increases in rural, urban and foreign demand do not balance increases in supply. More efficient agriculture, ceteris paribus, thus had a pauperizing effect on the rural population and increased urbanization and emigration. Thus, the factors sometimes mentioned as counteracting an agricultural crisis appear instead to have aggravated it.

2. Empirical research casts doubts on the general view of an agricultural crisis. Both rural wage and agricultural terms of trade rose. Our dynamic simulation creates a development path in correspondence with these findings. Industrialization increased demand for labor as well as rural goods. Rural-to-urban migration started to reallocate population. But the response was not strong enough to equilibrate rural and urban wages during the period of study. Even though our model is more complex than the simple two-sector model of a dualistic economy (see Chapter 2) a similar story is told. The agricultural sector was a bottleneck in the sense that growth of output was not large enough to balance the increase in demand as industrialization went on and thus increased terms of trade of agriculture as well as wages.

3. The links between domestic and foreign markets of agricultural goods did not have great impact on the path of development. The fall in world market prices during the 1880s increased domestic supply, lowered the price and rural wage, thus speeding up the process of urbanization. A larger capacity of the urban sectors increased industrialization and GNP per capita became higher. The fall in prices on agricultural goods thus strengthened Swedish development rather than causing an agricultural crisis.

6.3 THE ROLE OF EMIGRATION

Transatlantic migration was the most significant demographic change influencing the economic development in the late 19th century. Due to emigration the population increase was diminished by roughly 50 percent. The role of emigration, its causes and its consequences have been important issues when discussing the development of Sweden. However, there are few analyses of the effect of emigration on the Swedish economy.

Earlier studies

The first study is from the emigration period itself. Wicksell (1882) took a clear stand on the issue. Emigration was beneficial to Sweden because the country was overpopulated. His arguments were heavily influenced by the classical economists. Sweden was in his view endowed with a limited amount of arable land and natural resources. These resources yielded decreasing marginal returns. Swedish population was far larger than its optimum and further growth thus caused a pauperization of agriculture. Industrialization could not prevent this effect even though it counteracted it. The speed of industrialization lagged behind the growth of population. The only way to solve the pauperization problem was to limit the population. Emigration was only a second-best solution. Wicksell's preferences were to limit the natural increase of population. Large amounts of resources were wasted on education of children who later left the country as adults. However, it was not realistic to hope for a decrease in fertility and therefore emigration should be regarded as a positive factor in the development of Sweden.

Henricsson (1969) restates basically the same arguments in a study of the welfare consequences of emigration. He focuses on the effects on real wage. Henricsson points not only to the importance of the decreasing returns factor but also to the capital intensity factor and to the factor of technical progress. He argues that emigration was beneficial to Sweden by keeping its economy off from further decreasing returns, by raising the capital intensity and by stimulating technical progress. Henricsson's conclusions are based on qualitative arguments rather than quantitative estimations.

Dynamic counterfactual simulation: No emigration

The model developed in this study is appropriate to estimate some of the effects of emigration. Even though it cannot capture all the aspects which Henricsson points at as important, our model has some advantages. It incorporates both the demand and the supply sides of the economy and thus captures the crucial interaction between different markets. The disaggregation of the economy into five sectors makes it possible to analyze reallocation effects.

The importance of emigration is estimated by simulating a counterfactual development path for the period 1871-1890. This counterfactual history is compared with the base run of the model and the differences are interpreted as the consequences of the population being absorbed by the Swedish economy instead of migrating. It is difficult to design this counterfactual simulation. Are there additional complementary effects on exogenous variables and behavioral assumptions which should be incorporated? For example how is labor productivity influenced and how is rural--to-urban migration influenced?

Rural-to-urban migration is in this counterfactual simulation determined only by wages in the two regions

$$O/N_A = m1 - m2W_1 + m3W_2$$

This equation replaces equations 121 and 122. The weights on the wage variables are maintained, but the intercept of the migration function is now adjusted in order to achieve the same rural-to-urban migration in the base year in both cases. This is obviously a critical assumption. We can only guess what migration behaviour might have been in the absence of emigration. At the starting point in 1871, the situation is exactly the same in the counterfactual simulation as in the base run. Thus, we have not assumed any change in emigration before 1871. Our design of the counterfactual simulation can be interpreted as a hypothetical development path of the Swedish economy if emigration was prohibited by law after 1871 (assuming the law to be effective). There were in fact proposals in the early 1900s to legislate against emigration (Kälvemark, 1976).

The period 1871-1890 covers both a time of low emigration, the 1870s, and a time of high emigration, the 1880s. In 1880 and 1890 total Swedish population would have been 3 percent and 8.4 percent greater, respectively, had there been no emigration. The population projection automatically takes into account the expected population growth among emigrants assuming that fertility and mortality were the same among emigrants as among the rest of the population.

The immediate effect of precluding emigration is growth in the rural population, since emigrants come from rural rather than urban areas. In the base run rural population reaches a peak in 1880 and decreases by 0.5 percent per year (average rate) during the 1880s (see Table 6.4 and Appendix C, Table C.2). Eliminating emigration causes rural population to continue to grow. Rural population does not reach any turning point during the period of study, but Figure 6.6 indicates that rural population is almost stagnant in the 1880s. At the end of our counterfactual simulation, rural population is 10.4 percent higher and urban population 5.4 percent higher than in the base run.

Table 6.4 Counterfactual simulation: no emigration. Change in percent compared with the base simulation in each year.

	No emigration		No emigration + lower productivity in agriculture
	1880	1890	1880
Production in sector 1	2.8	7.1	-2.0
Production in sector 2	-0.8	6.9	0.7
Production in sector 3	0.7	3.7	-2.4
Production in sector 4	1.6	1.9	-0.4
Production in sector 5	-0.7	2.0	1.4
Rate of return on capital in agriculture	-3.5	-3.6	3.2
Rural wage	-5.1	-9.4	-0.4
Urban rate of return on capital	3.2	8.7	-4.4
Urban wage	1.7	2.2	-3.2
Investment	0.7	5.0	-1.2
GNP per capita	-1.6	-2.2	-4.1
Total population	3.0	8.4	2.9
Rural population	4.2	10.4	4.9
Urban population	0.4	5.4	-1.0
Rural capital stock	-0.3	-4.8	0.1
Urban capital stock	-0.2	0.6	0.2

The increase in rural population has both supply and demand effects on the commodity market. A greater supply of labor increases agricultural output (see Figure 6.8) and more population increases demand. A larger labor force, ceteris paribus, decreases the marginal productivity of labor, and this downward pressure on the rural wage is reinforced by a price fall on agricultural goods. Without emigration the agricultural wage starts to fall. The immediate changes are the same as in the counterfactual experiment No. I. When the counterfactual simulation is carried out over a longer period of time, migration moderates these effects. The enlarged wage gap between rural and urban areas increases rural-to-urban migration (see Figure 6.7). However, more internal migration does not outweigh emigration altogether during the period of study. The rural population is still larger in 1890 than in the base run. Thus the share of rural population decreases even though internal migration increases.

The larger urban population increases labor supply in absolute terms, and thus the capacity of urban industries grows. Capacity is also influenced by capital growth. During the 1870s there is a fall in savings and investment resulting in a somewhat smaller capital stock both in rural and urban regions compared with the base simulation. Rural capital stock is 0.3 percent lower and urban capital stock 0.2 percent lower. In agriculture the smaller capital stock has an insignificant effect on output. The urban region experiences a decrease in the 1880 production for sectors 2 and 5 and an increase in the production for sectors 3 and 4. The picture is completely different a decade later. Savings are greater both in rural and urban regions. There has also been a reallocation of the capital stock between the two regions. In 1890 the rural capital stock is 4.8 percent greater than in the base simulation. The increased capacity of the urban sectors is now more concentrated in the export-oriented sector. Its production is 6.9 percent higher. Although GNP growth is faster, it is not enough to counterbalance the increase in total population, so per capita GNP falls (see Figure 6.9). In 1880 it is 1.6 percent below and in 1890 2.2 percent below the figures in the base simulation.

Does emigration improve wages? The simulation indicates that agricultural wage is 5.1 percent lower in 1880 and 9.4 percent lower in 1890 without emigration. On the other hand the urban wages increase. In 1880 they are 1.7 percent higher and in 1890 2.2 percent higher than in our base simulation. But there is a tendency in the system to adjust and dampen the wage effect through the reallocation of factors. Thus, we can expect that both beneficial and harmful effects on wages in the two regions disappear as time goes by.

Figure 6.6 Rural population

Counterfactual simulation: No emigration.

Figure 6.7 Rural-to-urban migration

Figure 6.8 Production of agriculture

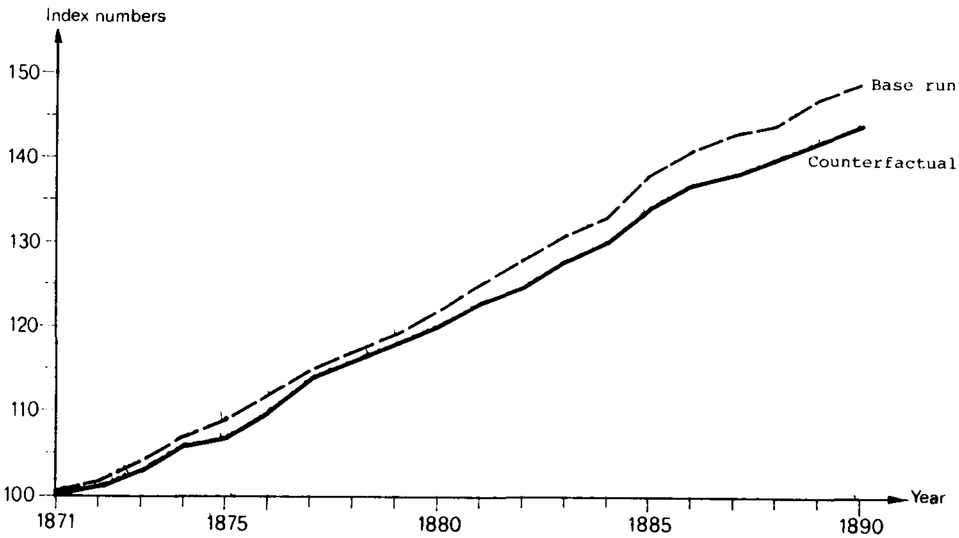
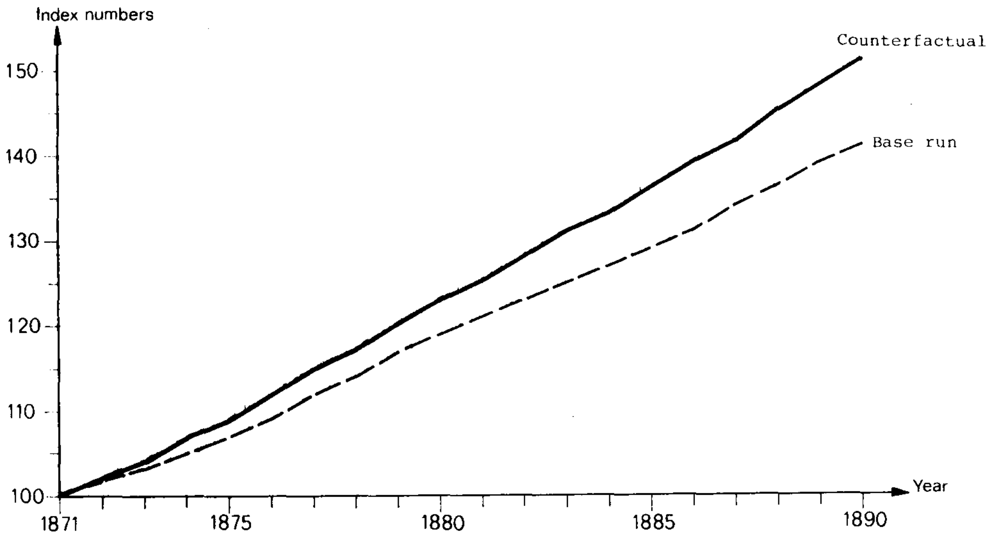


Figure 6.9 GNP per capita



<u>Dynamic counterfactual simulation: No emigration and lower agricultural productivity growth</u>

The efficiency of labor is closely linked to population and is exogenous in the model. The question occurs if and how the technical progress was influenced by emigration in the Swedish case. Henricsson (1969) argues that emigration speeded up technical change, but there are no studies that confirm this result. To evaluate the importance of this effect another counterfactual simulation was designed. In addition to prohibiting emigration, both labor- and capital-augmenting technical growth rates in agriculture are lowered. The growth rate of labor-augmenting technical change is 1.5 percent instead of 2.3 percent and the corresponding figure for capital is 0.5 percent instead of 1 percent. This simulation is only performed over the first 10 years. Some of the results are displayed in the last column of Table 6.4 (see also Appendix C).

The surprising result is that the negative effect on rural wage has almost totally disappeared. Decreasing productivity in agriculture results in a higher wage. The interaction with the commodity markets accounts for this result. Agricultural output is 2 percent lower compared with the base run instead of 2.8 percent higher as in the previous simulation. Consequently agricultural prices rise and this price effect counteracts the net decrease in productivity growth. The effect on return on capital is also reversed. It increases by 3.2 percent instead of decreasing by roughly the same magnitude. In the urban sector the complementary change in agricultural productivity causes significant differences between our two counterfactual histories. Return on factors of production diminishes, causing a drop in urban savings. Total savings and investment are also lower in this counterfactual simulation compared with the previous one. GNP falls relative to both the simulation without emigration and the base simulation. Per capita GNP is 4.1 percent below our base simulation in 1880.

Conclusions

We can summarize our findings as follows:

1. An analysis of the effects of emigration on the agricultural sector in isolation turns out to support the view of Wicksell and Henricsson. Emigration made the remaining people better off. The result is different if one includes the interaction between rural and urban sectors in the analysis. Emigration had a negative supply effect on agricultural output and caused a significant rise in the price of agricultural goods. Terms of trade between agriculture and industry were further improved

from the point of view of agriculture. Urban income deteriorated and savings and investments diminished. A smaller population thus dampened the reallocation of resources from rural to urban sectors; especially hit were the export-oriented industry.

2. The effects of emigration on the rural wage are unclear. Indeed we observed a huge wage reduction in our first counter-factual simulation, but considering the complementary effect of emigration on productivity the conclusion is not clear. The influence on rural wage depends heavily on the complementary effect on productivity. If productivity increased because of emigration the rural wage surprisingly falls even more. The indirect effects via the commodity markets cause this result. As long as we do not know how emigration influenced productivity, clear determination of its welfare effects is not possible. Emigration has also a significant influence on the distribution of income and growth rates in the urban sectors. However, the result depends once again on the complementary productivity effect in agriculture.

3. Emigration did not in a more fundamental meaning change the development path of Swedish economy. Even without emigration and lower productivity increases in agriculture there is, for example, a significant rise in the rural wage during the period of study. Factors other than the transatlantic migration determined the process of growth.

NOTE

1) The wage figures are deflated by the price on rye.

APPENDIX A
MATHEMATICAL STATEMENT OF THE MODEL

A:I The Model of Temporary Equilibrium

Sector subscripts

A rural agricultural region (= sector 1)

U urban region (= sectors 2-5)

1 agriculture, forestry and fishing

2 export-oriented industry

3 homemarket-oriented industry

4 services

5 building and construction

Income superscripts

ℓ income from wages

c income from capital

Endogenous variables

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

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

P_i^* value-added prices in sector i = 1, ..., 5

X_i production in sector i = 1, ..., 5

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

H_1 composite of labor and capital input

L_i employment in sector i = 1, ..., 5

L_U employment in urban region

W_i wage rate in sector i = 1, ..., 5

W_U wage in the urban sector

Q_i user cost of capital in sector i = 1, ... 5

C_i net return on capital in sector i = 2, ... 5

C_U rate of return on capital in the urban sector

K_i capital stock in sector i = 2, ..., 5

q_j supernumerary income in region j = A, U

Y_j^i consumption expenditure from income of i (i = labor (ℓ) or capital (c)) in region j = A, U

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

Z_i export of commodity i = 1, ..., 4

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

S_j private savings in region j = A, U

S^G savings by government

S total savings

I_j investment goods produced in sector j = 2, 5

I total investments

Exogenous variables and parameters

P_i^W prices expressed in Swedish currency on international markets on commodity i = 1, ..., 3

h_j labor augmenting technological change in sector j = 1, ..., 5

g_j capital augmenting technological change in sector j = 1, ..., 5

ρ_j substitution parameter in sector j = 1, ..., 5

α, δ_j, γ_j distribution parameters in the production functions in sector j = 1, ..., 5

A_j constant in the production functions in sector j = 1, ..., 5

a_{ij} input of commodity i = 1, ..., 5 per unit of output in sector j = 1, ..., 5

p_j labor participation rate in region j = A, U

N_j total population in region j = A, U

K_j capital stock in region j = A, U

R_1 total land acreage

G consumption expenditure by government

F net capital inflow

T remittances from emigrants

ω_j constant in the wage equation in sector j = 2, ..., 5

σ_j constant in the equation determining rate of return on capital in sector j = 2, ..., 5

β_{ij} marginal propensity to consume commodity i = 1, ..., 5 by households in region j = A, U

b_{ij} per capita subsistence consumption of commodity i = 1, ..., 5 in region j = A, U

s^{ℓ}, s^{c} rate of savings from labor (ℓ) and capital (c) income

ε_i price elasticity parameter in export demand for commodity i = 1, ..., 3

μ_i price elasticity parameter in import demand for commodity i = 1, ..., 3

V_i index of world market trade with commodity i = 1, 3

$\bar{M}_i$ constant parameter in import demand of commodity i = 1, ..., 3

$\bar{Z}_i$ constant parameter in export demand of commodity i = 1, ..., 3

ν export share in sector 4

τ^{ℓ}, τ^{c} tax rate from labor (ℓ) and capital (c) income

ι_j annual rate of depreciation of buildings and plants in sector j = 1, ..., 5

κ_j annual rate of depreciation of other capital goods in sector j = 1, ..., 5

Π_j profit in sector j = 1, ..., 5

r rent on land

Φ_j share of buildings and plants in the capital stock of sector j = 1, ..., 5

ξ_j share of total investments produced in sector j = 2, 5

Production functions

$$X_1 = A_1 R_1^{\alpha} H_1^{1-\alpha} \tag{1}$$

$$H_1 = \left\{\delta_1(g_1K_1)^{-\rho_1} + \gamma_1(h_1L_1)^{\rho_1}\right\}^{-1/\rho} \tag{2}$$

$$X_j = A_j\left\{\delta_j(g_jK_j)^{-\rho_j} + \gamma_j(h_jL_j)^{-\rho_j}\right\}^{-1/\rho_j} \quad j = 2,\ldots,5 \tag{3-6}$$

Intermediate demand

$$X_{ij} = a_{ij} X_j \quad i = 1,\ldots,5 \; ; \quad j = 1,\ldots,5 \tag{7-31}$$

Net prices

$$P_i^* = P_i - \sum_{j=1}^{5} P_j^D a_{ji} \quad i = 1,\ldots,5 \tag{32-36}$$

Labor demand

$$\frac{W_1L_1}{P_1^*X_1} = (1-\alpha)\gamma_1\left(\frac{H_1}{h_1L_1}\right)^{\rho_1} \tag{37}$$

$$\frac{W_jL_j}{P_j^*X_j} = \gamma_j\left(\frac{X_j}{h_jL_jA_j}\right)^{\rho_j} \quad j = 2,\ldots,5 \tag{38-41}$$

Labor supply

$$L_j = p_j N_j \quad j = A, U \tag{42-43}$$

Capital demand

$$\frac{Q_1 K_1}{P_1^* X_1} = (1-\alpha)\delta_1 \left(\frac{H_1}{g_1 K_1}\right)^{\rho_1} \qquad (44)$$

$$\frac{Q_j K_j}{P_j^* X_j} = \delta_j \left(\frac{X_j}{g_j K_j A_j}\right)^{\rho_j} \qquad j = 2, \ldots, 5 \qquad (45\text{-}48)$$

Sectoral wages

$$W_j = \omega_j W_U \qquad j = 2, \ldots, 5 \qquad (49\text{-}52)$$

User cost of capital

$$Q_j = P_2^D (C_j + \varkappa_j)(1-\Phi_j) + P_5^D (C_j + \iota_j)\Phi_j \qquad j = 2, \ldots, 5 \qquad (53\text{-}56)$$

Sectoral rate of return on capital

$$C_j = \sigma_j C_U \qquad j = 2, \ldots, 5 \qquad (57\text{-}60)$$

Factor market clearing

$$\sum_{j=2}^{5} L_j = L_U \qquad (61)$$

$$\sum_{j=2}^{5} K_j = K_U \qquad (62)$$

Household income

$$q_j = \sum_{i=1}^{5} b_{ij} P_i^D N_j \qquad j = A, U \tag{63-64}$$

$$Y_A^{\ell} = [(1-\tau^{\ell})W_1L_1 + T - q_A](1-s^{\ell}) + q_A \tag{65}$$

$$Y_A^{c} = (1-\tau^{c})(P_1^*X_1 - W_1L_1)(1-s^{c}) \tag{66}$$

$$Y_U^{\ell} = \left[(1-\tau^{\ell}) \sum_{j=2}^{5} W_jL_j - q_U\right](1-s^{\ell}) + q_U \tag{67}$$

$$Y_U^{c} = (1-\tau^{c}) \sum_{j=2}^{5} Q_jK_j(1-s^{c}) \tag{68}$$

Household demand

$$P_i^D D_{ij} = N_j b_{ij} P_i^D + \beta_{ij}[(Y_j^{\ell}+Y_j^{c}) - q_j] \qquad \begin{matrix} j = A, U \\ i = 1, \ldots, 5 \end{matrix} \tag{69-78}$$

Domestic prices

$$P_i^D = \frac{M_i}{M_i + (X_i-Z_i)} P_i^W + \frac{X_i - Z_i}{M_i + (X_i-Z_i)} P_i \qquad i = 1, 3 \tag{79-80}$$

$$P_2^W = P_2^D \tag{81}$$

$$P_i^D = P_i \qquad i = 2, 4, 5 \tag{82-84}$$

Import

$$M_i = \bar{M}_i \left(\frac{P_i}{P_i^W}\right)^{\mu_i} (X_i - Z_i) \quad i = 1,\ 3 \tag{85-86}$$

$$M_2 = \bar{M}_2 (X_2 - Z_2) \tag{87}$$

Export

$$Z_i = \bar{Z}_i \left(\frac{P_i}{P_i^W}\right)^{\varepsilon_i} V_i \quad i = 1,\ 3 \tag{88-89}$$

$$Z_4 = \nu \sum_{i=1}^{3} Z_i \tag{90}$$

Current account

$$F + T = \sum_{i=1}^{3} P_i^W M_i - \sum_{i=1}^{4} P_i Z_i \tag{91}$$

Savings

$$S_A = s^\ell [(1-\tau^\ell) W_1 L_1 + T - q_A] + s^c (P_1^* X_1 - W_1 L_1)(1-\tau^c) \tag{92}$$

$$S_U = s^\ell [(1-\tau^\ell) \sum_{j=2}^{5} W_j L_j - q_U] + s^c \sum_{j=2}^{5} Q_j K_j (1-\tau^c) \tag{93}$$

$$S^G = \tau^\ell \sum_{j=1}^{5} W_j L_j + \tau^c \left(\sum_{j=2}^{5} Q_j K_j + P_1^* X_1 - W_1 L_1 \right) - P_4^D G \tag{94}$$

$$S = S_A + S_U + S^G + F \tag{95}$$

Demand for investment goods

$$I_5 P_5^D = \xi I \tag{96}$$

$$I_2 P_2^D = (1-\xi) I \tag{97}$$

Commodity market equilibrium

$$X_1 = D_{1A} + D_{1U} + \sum_{j=1}^{5} a_{ij} X_j + Z_1 - M_1 \tag{98}$$

$$X_2 = D_{2A} + D_{2U} + \sum_{j=1}^{5} a_{2j} X_j + I_2 + Z_2 - M_2 \tag{99}$$

$$X_3 = D_{3A} + D_{3U} + \sum_{j=1}^{5} a_{3j} X_j + Z_3 - M_3 \tag{100}$$

$$X_4 = D_{4A} + D_{4U} + \sum_{j=1}^{5} a_{4j} X_j + G + Z_4 \tag{101}$$

$$X_5 = D_{5A} + D_{5U} + \sum_{j=1}^{5} a_{5j} X_j + I_5 \tag{102}$$

Gross national product

$$GNP = \sum_{i=1}^{5} P_i^D X_i - \sum_{i=1}^{5} \sum_{j=1}^{5} P_i^D X_{ij} \tag{103}$$

A:II The Dynamic Model

Endogenous variables

I total investment

I_j investment in region $j = A, U$

S_j savings in region $j = A, U$

Q_j user cost of capital in sector $j = 1, \ldots, 5$

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

O total outmigration from rural region

E emigration from Sweden

N_j total population in region $j = A, U$

W_j wage in rural and urban regions $j = 1, 2$

SF savings fund

Exogenous variables and parameters

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

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

R_1 total land acreage

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

V_j index of world market trade with commodity $j = 1, 3$

z share of savings directly invested in sector of origin

ι_j annual rate of depreciation of buildings and plants

$\varkappa_j$ annual rate of depreciation of other capital goods in region $j = A, U$

Φ_j share of buildings and plants in the capital stock of region $j = A, U$

λ_j annual rate of labor augmenting technological change in sector j = 1, ..., 5

χ_j annual rate of capital augmenting technological change in sector j = 1, ..., 5

$m_1 \ldots m_7$ parameters in the migration functions

B_{US} index of business cycles in the United States

W_{US} wage in the United States

ζ_j net natural rate of population increase in region j = A, U

Θ_j growth rate of labor participation rates j = A, U

ψ_j growth rate of world market j = 1, 3

η annual rate of growth in land acreage

Investment allocation

$$SF = (1-z)(S_A+S_U) \tag{104}$$

$$I_A = z\ S_A + \frac{Q_i}{\sum_{i=1}^{5} Q_i} SF \tag{105}$$

$$I_U = S^G + zS_U + \frac{\sum_{i=2}^{5} Q_i}{\sum_{i=1}^{5} Q_i} SF + F \tag{106}$$

Growth of capital stock

$$K_j(t) = K_j(t-1)+I_j(t-1)-[\iota_j\Phi_j+ \varkappa_j(1-\Phi_j)]K_j(t) \qquad j=A,U \tag{107-108}$$

Productivity growth

$$g_j(t) = g_j(t-1)\exp(\chi_j) \quad j = 1, \ldots, 5 \tag{109-113}$$

$$h_j(t) = h_j(t-1)\exp(\lambda_j) \quad j = 1, \ldots, 5 \tag{114-118}$$

Growth of land

$$R_1(t) = R_1(t-1)\exp(\eta) \tag{119}$$

World market growth

$$V_j(t) = V_j(t-1)\exp(\psi_j) \quad j = 1, 3 \tag{120-121}$$

Migration

$$O/N_A = m1 - m2W_A + m3W_2 + m4B_{US} \tag{122}$$

$$E/O = m5 - m6\frac{W_{US}}{W_2} + m7B_{US} \tag{123}$$

Population growth

$$N_A(t) = N_A(t-1)(1+\zeta_A) - O(t-1) \tag{124}$$

$$N_U(t) = N_U(t-1)(1+\zeta_U) + O(t-1) - E(t-1) \tag{125}$$

Labor participation rate

$$p_j(t) = p_j(t-1)\exp\theta_j \quad j = A, U \tag{126-127}$$

APPENDIX B

THE DATA BASE

Estimating all the parameters in our model with conventional econometric methods would be an impossible task. For some variables no time series exist. Instead, we have followed procedures that have been developed in recent years when implementing CGE-models. A consistent data set in the form of an input-output table is constructed. Quantities are chosen such that all relative prices are unity in the base year. We can then calculate many parameters of the model from the general equilibrium conditions using data in the input-output table.

But an input-output table for the base year is not enough. To get figures on all the parameters in the model we have in many cases picked figures from other studies and in some cases been forced to guess. In the following sections the principles that have been followed and the assumptions that have been made to put together a consistent data base will be discussed.

B.1 Input-Output Tables

The input-output table for 1871 is the basic data set but we have also constructed tables for 1880, 1890, 1900, and 1910. (Tables 1, 2, 3, 4, and 5). The main sources have been Johansson (1967) and Lindahl et al. (1937). The data base has been elaborated in various ways so that, for instance, the sector division matches the structure of the model. In the following sections the principles that have been followed and the assumptions that have been made to construct these input-output tables will be discussed.

Table 1. Input-output table 1871 (market prices).

From \ To	1	2	3	4	5	$\sum$	I	C_P	C_G	Ex	Im	Total prod.
1. Agriculture	127	44	121	---	--	292	--	307	--	52	50	601
2. Export-oriented	1	13	20	7	5	46	22	17	--	92	16	161
3. Home market-oriented	11	26	41	5	4	87	--	338	--	15	115	325
4. Services	69	16	93	6	3	187	--	173	54	28		442
5. Building and construction	5	1	1	28	--	35	50	---	--	---		85
$\sum$	213	100	276	46	12	647	72	835	54	187	181	1614
Wage sum	271	50	26	95	51							
Depreciation	15	5	2	27	1							
Profit	102	6	21	274	21							
Total production	601	161	325	442	85							

Table 2. Input-output table 1880 (market prices).

From \ To	1	2	3	4	5	$\sum$	I	C_P	C_G	Ex	Im	Total prod.
1. Agriculture	144	72	151	---	---	367	---	364	--	57	66	722
2. Export-oriented	1	22	28	8	20	79	26	36	--	135	26	245
3. Home market-oriented	19	38	47	10	6	120	---	513	--	36	202	467
4. Services	56	20	180	14	5	270	---	216	77	42	---	605
5. Building and construction	9	1	2	35	---	47	100	---	--	---	---	147
$\sum$	303	153	408	67	31	883	126	1119	77	270	294	2181
Wage sum	363	70	40	154	90							
Depreciation	17	10	5	56	1							
Profit	113	12	14	328	25							
Total production	722	245	469	605	147							

Table 3. Input-output table 1890 (market prices).

From \ To	1	2	3	4	5	$\sum$	I	C_P	C_G	Ex	Im	Total prod.
1. Agriculture	161	89	216	---	---	466		356	--	31	108	745
2. Export-oriented	4	44	53	13	23	137	56	63	--	167	54	369
3. Home market-oriented	27	53	62	16	12	170	---	635	--	76	252	629
4. Services	67	40	229	16	10	362	---	241	95	47	---	745
5. Building and construction	11	2	2	42	---	57	93	----	--	---	---	150
$\sum$	270	228	562	87	45	1192	149	1295	95	321	414	2638
Wage sum	384	106	60	181	89							
Depreciation	23	20	5	76	1							
Profit	68	15	2	401	15							
Total production	745	369	629	745	150							

Table 4. Input-output table 1900 (market prices).

From \ To	1	2	3	4	5	$\sum$	I	C_P	C_G	Ex	Im	Total Prod.
1. Agriculture	199	135	295	----	---	629	---	513	---	25	157	1010
2. Export-oriented	6	102	122	22	57	309	110	119	---	376	102	712
3. Home market-oriented	48	140	167	42	43	440	---	962	---	83	324	1161
4. Services	110	66	346	32	15	569	---	465	128	75	---	1237
5. Building and construction	18	4	4	55	---	81	191	----	---	---	---	272
$\sum$	381	447	934	151	115	2028	301	2059	128	459	583	4392
Wage sum	523	203	130	253	149							
Depreciation	26	27	14	97	2							
Profit	80	35	83	737	6							
Total production	1010	712	1161	1237	272							

Table 5. Input-output table 1910 (market prices).

From / To	1	2	3	4	5	$\sum$	I	C_P	C_G	Ex	Im	Total prod.
1. Agriculture	310	161	385	----	---	865	---	738	---	26	201	1419
2. Export-oriented	12	199	206	45	85	547	148	203	---	411	132	1177
3. Home market-oriented	82	151	157	53	62	505	---	1428	---	120	393	1660
4. Services	155	116	549	61	22	903	---	442	210	102	---	1657
5. Building and construction	23	6	6	82	---	117	219	----	---	---	---	336
$\sum$	582	633	1303	241	169	2928	367	2811	210	659	726	6249
Wage sum	623	297	209	511	157							
Depreciation	82	41	17	164	2							
Profit	132	206	131	741	8							
Total production	1419	1177	1660	1657	336							

In Johansson's (1967) estimates of the Swedish domestic product between 1861 and 1955, he presents sectoral production accounts for seven different sectors. They show, on the credit side, the value of gross output and its distribution among various users, and on the debit side, the value of inputs of goods and services from own and other sectors. This information makes it possible to obtain the intermediate deliveries between sectors.[1] Deliveries to model sectors 2 and 3 cause some problems, because Johansson presents no production account for industrial subgroups - just for the total manufacturing industry and handicrafts. Deliveries from the subgroups can be identified but not the deliveries to them. One can assume that the input structures of the two manufacturing sectors are rather different. The most important intermediate delivery to the manufacturing industry is from agriculture. When disaggregating to conform to the structure of the model, the following assumptions are made: 90 percent of deliveries from the agricultural subgroup "forestry" are assumed to be directed to the export-oriented sector (of which wood product industries are a part), 95 percent of the remaining deliveries from agriculture are assumed to go into the homemarket-oriented sector (of which the food product industries receive the main share)[2], and the remaining five percent to sector 2. To break down the deliveries to manufacturing industries into the two model sectors 2 and 3, we have assumed the same input-output coefficients for both sectors.[3] With these procedures all intermediate flows can be identified in the model.

Elaboration on the final demand side of the input-output table is straightforward from Johansson's estimates.[4] The only problem is the import figures. The proper valuation of import in an input-output table expressed in market prices is to include the custom duties on the imported values. Johansson's summary import tables are reported cif, so the figures have been adjusted accordingly. By summing Johansson's imports (including custom duties) for consumption, intermediate deliveries and investments for each sector, it is possible to obtain the proper import figures.

To obtain an input-output table in market prices, further adjustments have to be made to incorporate trade margins and transportation costs. Johansson has also estimated the contribution of commerce and transportation to Swedish GNP. The value of services from the commerce sector has been calculated "as certain percentages of the part of gross output valued at factor cost of agriculture, forestry, manufacturing industry, and import allocated to consumption" (Johansson 1967:184). In order to include trade markups in the value of production for various sectors, the same principles have been used as those underlying the original estimates (see Lindahl et al. 1937:484-487).

The following procedure has been followed. The total value of the trade markups is by definition equal to gross output of commerce and has in Johansson's estimates been treated as final consumption and export income. We have instead treated them as intermediate deliveries from the commerce sector to the other consumer-goods-producing sectors. Consumption and export of the service sector will thus be reduced, but its intermediate deliveries increase, so gross output will be unchanged. The trade markups on exported goods are displayed in Johansson (Table 34). When allocating the trade markups for domestic goods among sectors, the criterion of distribution has been each sector's share of domestic consumption. Before calculating that share we have taken into consideration that a large share of agricultural output never is distributed via the market and thus no trade markups were included. This share of agricultural consumption has roughly been approximated by the share of rural population in total population. Trade markups on exported goods are allocated by using sectoral export shares as allocation criteria. By making use of the information on domestic transportation costs published in Lindahl et al. (1937:444), we have included transportation markups in the valuation of consumption and gross outputs of various sectors. The same allocation rules as for trade markups have been applied.

The distribution of functional income in the input-output tables is obtained by somewhat more indirect measurements. First the total wage bill has been determined for each sector by using our estimates of sectoral wages and employment (see below for further details of the calculations). We have information about sectoral depreciation for the capital stock data (see below). The profit for each sector is then simply obtained as a residual.

The input-output coefficients (a_{ij}) and the constant scaling factor in each production function A_j are calculated from the input-output table for 1871.

B.2 Population, Employment, and Labor Participation

Data on population are taken from Historical Statistics of Sweden 1969 (Table 23, p. 82) and displayed in Table 6.

Table 6. Population and labor participation rates 1871-1890

	Population		Participation rate	
	Rural	Urban	Rural	Urban
1871	3043.8	1160.4	0.345982	0.435367
1880	3102	1464	0.250580	0.431216
1890	2973	1812	0.358560	0.377539

Source: Historical Statistics of Sweden (1969, Table 23, p. 82).

Labor participation rates are an exogenous variable in the model and specific to urban and rural areas (p_U and p_A). They are calculated for benchmark years simply by dividing employment in rural and urban areas by their population (see Table 6). A linear trend is assumed between these different points of time in the dynamic simulations.

There are employment statistics available for many sectors of the Swedish economy. These series start in 1870, and can be found in Jungenfelt (1966, Appendix B, Table 1-4). The main source for agriculture is the Population Censuses which were undertaken every ten years during the second part of the 19th century. To calculate employment for the years between these benchmark years, various principles have been applied (see Jungenfelt 1959:16). For the first decade of our analysis, the 1870s, a linear trend has been assumed between the two census years 1870 and 1880. Between 1880 and 1890 emigration has been used as an aid in allocating total change between 1880 and 1890 for the intermediate years. Between 1900 and 1910 internal rural-to-urban migration has been used as the indicator. These principles of interpolation make the yearly employment data less useful for this study. They imply some implicit assumptions. For example, between 1880 and 1890 it is assumed that fluctuations in internal migration were unimportant, but during the next decade the completely opposite assumption is made about fluctuations of employment in agriculture. Our study focuses on the dynamic interaction between internal and external migration and therefore employment figures that incorporate a predetermined relationship should be avoided. Therefore we have used employment data only for the census years (with the exception of the starting year 1871).

The following sources and principles were used to obtain data on employment in the five different model sectors for each of the years for which an input-output table is constructed. The figures are displayed in Table 7.

Table 7. Employment 1871-1910 (thousands)

	Sector					Urban
Year	1	2	3	4	5	∑ 2-5
1871	1053.1	98.2	80.3	242.2	84.5	505.2
1880	1087.5	116.9	95.7	292.7	126.0	631.3
1890	1066.0	154.0	120.6	302.1	107.4	684.1
1900	1051.2	231.4	189.4	334.7	151.8	907.3
1910	979.1	272.4	222.9	456.1	130.5	1081.9

The data on agricultural employment are taken from Jungenfelt (1966, Appendix B, Table 1). The total employment in industry and handicrafts is given in Jungenfelt (1966, Table 1). For some of the subsectors, more disaggregated data are available (Jungenfelt 1966, Table 2). These figures imply that roughly 45 percent of the employees were employed in the homemarket--oriented sector. The share remains fairly unchanged over time, and has been used to divide total industrial employment between model sectors 2 and 3.

Statistics exist for only parts of the sectors contributing to the service sector. The missing subsectors are commerce and professional services. However, some indications of employment are given for the years of population censuses (Jungenfelt 1959:53-54). Even though one can assume that the census figures are too low we have used them and added them to employment in the remaining subsectors - transporation, domestic service, and public administration (Jungenfelt 1966:226).

The figures on employment in building and construction activities published in the Population Censuses are very unreliable for the 19th century. The figures underestimate actual employment because many workers were only partly engaged in building activities and therefore classified in other sectors. Therefore, another procedure is chosen to estimate employment in this sector. The more reliable data starting in 1930 are used. It is assumed that value added in fixed prices per unit of efficiency labor is stable and equal to the level of 1930. Labor productivity is assumed to increase by 0.5 percent per year before 1930. Employment is calculated for each of the benchmark years making these assumptions.

B.3 Wages

The wage statistics for the earlier part of the Swedish industrialization are very disaggregated. We have put together these data for two reasons. The first is that to complete our input-output tables we have to know the total wage bill in various sectors. The second reason is that a certain wage structure is assumed between the urban sectors and by using the wage statistics we are able to estimate these parameters (ω_j). In this section the sources and the elaborations that have been undertaken are described.

The agricultural wage is calculated by dividing the wage sum by total employment (Jungenfelt 1966, Appendix B, Tables 1 and 7). There are no difficulties in getting wages for model sectors 2 and 3 because data on employment and wages are published for eight industrial subgroups (Jungenfelt 1966, Tables 2 and 6). The wage of the export-oriented sector is thus a weighted average of wages in mining and metal industries, wood product industries, and paper, pulp, and printing industries. Employment in the various sectors is used as weights. The wage of the homemarket-oriented sector is made up of wages in clay, stone, and glass industries, the food product industries, the textile industries, and the power, gas, and water works.

Wage data exist for every subsector of the service sector from 1910. Before this year statistics are missing for commerce and other professional services. A wage is calculated for the whole period as a weighted average of all subsectors constituting the service sector except commerce. This wage is probably too low because the missing subsectors are high-salary sectors. They include banking and insurance and professional services such as lawyers and dentists. Therefore an average wage including these subsectors was calculated for the year 1910. This wage is nine percent higher than the wage excluding commerce and professional services. In order to adjust for this underestimate for the period before 1910, the wage of the service sector has been increased by nine percent each year.

No statistics are available that can be used to calculate a wage for the building and construction sector. Wage data for the 1930s indicate that the sector was paid a rather high wage. We have simply assumed that the wage in this sector is 20 percent higher (up until 1900 and thereafter ten percent higher) than the wage in the export-oriented sector.

Table 8. Wages 1871-1910 (Skr)

	Sector				
Year	1	2	3	4	5
1871	258	503	322	391	604
1880	334	596	412	527	715
1890	360	689	498	599	829
1900	498	876	687	755	1051
1910	636	1093	936	1121	1312

B.4 Capital Stock and Depreciation Rates

Data on the capital stock in different sectors are available in a study by Parks (1966). Using the perpetual inventory method and investment figures published by Johansson (1967), he estimated sectoral capital stocks from 1870 to 1955. Parks' data on capital stocks, their disaggregation into equipment and buildings (and livestock in agriculture), as well as his estimates on depreciation rates are used in this study. In order to fit the model, the data have to be somewhat elaborated. The following recalculations have been undertaken.

First, Parks' data have to be deflated. A price deflator for capital goods estimated by Krantz and Nilsson (1975) has been used. Livestock has been added to equipment in agriculture. This treatment is followed by adding investment goods produced in agriculture to sector 2's production of investment goods (see Section B.10). No disaggregated capital stock figures are published for subsectors of manufacturing and industry. Therefore disaggregation has been obtained by assuming a higher capital/ /value added ratio in sector 2. It is assumed that the capital/ /value added ratio is about 1.5 times higher in sector 2 than in sector 3.

Parks' estimates of the capital stock for building and construction seem to be too low. According to his figures, no capital stock existed before 1880. We have therefore adjusted the level of capital stock in this sector upward. We show the figures on the capital stocks in different sectors in Table 9 for the benchmark years. Parks' method of estimating capital stocks incorporates information on total depreciation in different sectors and rates of depreciation. These figures were aggregated to match the structure of the model and then used to complete the input-output tables. They were also used to calculate the depreciation parameters in the model. The depreciation parameters were assigned the following values:

Depreciation on buildings in agriculture	ι_i	0.007
Depreciation on other capital in agriculture	$\varkappa_1$	0.015
Depreciation on buildings in the urban sectors (i = 2 ... 5)	ι_i	0.016
Depreciation on other capital in the urban sector (i = 2 ... 5)	$\varkappa_i$	0.05

A certain structure of relative rates of return was imposed in the model. Their values have been obtained by dividing sectoral profits in the input-output tables by the capital-stock figures. Remember that the data on sectoral profits were obtained residually and are thus highly uncertain.

Table 9. Capital stock 1871-1910 (current prices)

	Sector					
Year	1	2	3	4	5	$\sum$ 2-5
1871	1423.0	109	58	1553.0	10	1730.0
1880	1588.5	190	86	2123.8	12	2411.0
1890	1582.0	320	86	2382.0	13	2801.0
1900	1729.0	410	207	3209.0	17	3842.0
1910	2064.0	695	284	4418.0	20	5416.0

B.5 Production Parameters

With the assumption that all relative prices are unity in the base year, the parameters in the production functions can be calculated. The first order conditions for profit maximization (equations 38-41 and 45-48) were used for the calculations of the distribution parameters (γ_j, δ_j) in the CES function used in the urban sectors:

$$\gamma_j = \frac{W_j L_j}{P_j^* X_j} \Bigg/ \left(\frac{X_j}{A_j h_j L_j}\right)^{\rho_j} \qquad (38\text{-}41)$$

$$\delta_j = \frac{Q_j K_j}{P_j^* X_j} \Bigg/ \left(\frac{X_j}{A_j g_j K_j}\right)^{\rho_j} \qquad (45\text{-}48)$$

Data on sectoral wage bills, total profits, and sectoral production are available in the input-output table of 1871. Figures on capital and labor employment in the different sectors were calculated (see Sections B.3 and B.5). Estimates by Jungenfelt (1966:202) of the elasticity of substitution in industry, transportation, and agriculture were used to get values of the substitution parameters, defined as

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

where ε_s is the elasticity of substitution. Jungenfelt estimated the elasticities to be 0.6 in all sectors. This figure was applied to all the model sectors. With these data available, calculations of the distribution parameters are straightforward. In agriculture the first order conditions look slightly different (see equations 37 and 44) because a nested production function is used. We also have assumed that α, the share of land of value-added, is 0.2 in 1871.

The acreage of land has been estimated for the period of study by Holgersson (1974). According to his calculations cultivated acreage increased from 3,286,000 hectares in 1867/71 to 3,677,000 hectares in 1910/13. We have assumed a constant growth between these two points (average annual growth rate of 0.26 percent).

The parameters for which it has been most difficult to obtain empirical data have been the rates of technical growth. The growth rates used have been obtained in the following way. The model has been updated (i.e., the exogenous variables set to their historical values) ten years. Instead of making sectoral output endogenous, they have been fixed at their historical figures (expressed in the relative prices of the base year). Capital-augmenting technical progress has been assumed to have a certain growth rate over the ten-year period. The model has then been solved, keeping the labor-augmenting parameters in the production functions endogenous. The growth rates used were based on this procedure. The rates of growth calculated for the year 1880 were held constant for the period of study 1871--1890. The rates are displayed in Table 10.

Table 10. Factor-augmenting technical growth (percent per year), 1871-1890

	Sector 1		Sector 2		Sector 3		Sector 4		Sector 5	
	g*	h**	g	h	g	h	g	h	g	h
1871-1890	1.0	2.28	2.16	4.93	0	0.5	0	1.3	0	0

* g = capital-augmenting technical growth
** h = labor-augmenting technical growth

B.6 Demand parameters

In the model a so-called linear expenditure system, LES, is applied

$$D_i = b_i N + \frac{\beta_i}{P_i^D} (Y - q_i) \tag{B.1}$$

The Engel elasticity (ε_{ei}) can be obtained by differentiation

$$\varepsilon_{ei} = \frac{\partial D_i}{\partial Y} \frac{Y}{D_i} = \beta_i \frac{Y}{P_i^D D_i} \tag{B.2}$$

We can estimate β_i if we know the Engel elasticity and the budget share for each commodity i,

$$\beta_i = \varepsilon_{ei} \frac{P_i^D D_i}{Y}$$

The Engel elasticities we have used are based on estimates by Parks (1969). His estimates cover the period 1861-1955, but he used a different sector division than we do, and therefore his estimates cannot be directly applied. The average budget shares are taken from the input-output tables. These estimates are shown in Table 11.

Table 11. Demand parameters, 1871

Sector	Budget share	Engel elasticity	Marginal propensity to consume (β_i)	Subsistence consumption (b_i)
1	0.2677	0.400	0.14708	0.0584
2	0.0203	1.400	0.02842	0.0012
3	0.4048	1.400	0.56672	0.0241
4	0.2072	1.244	0.25778	0.0156

If equation (B.1) is inserted in equation (B.2) the following expression can be derived with some manipulation. Remember that all relative prices are 1 in the base year.

$$b_i N = Y\left(\frac{D_i}{Y} - \beta_i \frac{Y-q}{Y}\right)$$

If we know the ratio (Y-q)/Y the subsistence consumption parameters, b_i, can be calculated in the base year. We have assumed that the ratio is equal to 0.5 in 1871. This magnitude is sometimes even claimed as a stylized fact (Taylor 1979:219).

There was assumed to be no difference between rural and urban demand patterns in the base run of the model. The demand parameters for the first year of calibration, 1871, are displayed in Table 11.

B.7 Exports and Imports

Because of the very poor data on foreign trade most of the parameters in the import and export functions are based on qualitative considerations.

The constant in the export functions can be estimated in the base year when price ratios are assumed to be 1 (world market prices are set to 1 in the base year). The constants, $\bar{Z}_1$ and $\bar{Z}_3$ are therefore simply equal to the export shares in these sectors in the base year. The same applies for the constants in the import functions ($\bar{M}_1$, $\bar{M}_2$, $\bar{M}_3$). They are the share of import in domestic supply in the base year.

The import and export elasticities were assumed as shown in Table 12.

Table 12. Parameters of exports and imports

	Parameters					
	Export elasticities		Import elasticities		Growth rate of world market in percent (ψ_j)	
Period	1	3	1	3	1	3
1871-1890	-2.5	-2.0	0.7	4.5	2	4.5

Annual growth rate of the world market for each model sector is needed in the export functions. We have not been able to find such disaggregated figures but there are some estimates of the growth rate of total world trade (Ohlsson 1969:3). During the post-World War I period it grew at an annual rate of 3.4 percent (volume values). This figure has been somewhat adjusted and used in export functions of sectors 1 and 3 (see Table 13). The exogenous import share of sector 2 ($\bar{M}_2$) was assumed to increase at a rate of 1.78 percent between 1871 and 1890.

Export of sector 4, mainly shipping revenues, were assumed to be a fixed share ν of the remaining exports. This share was calculated from the input-output table and kept constant.

B.8 Public Consumption and Taxes

Public consumption (G) is exogenously determined in the model. It includes both government and local administration. The figures were taken from Johansson (1967:115), where also a discussion about the definition of public expenditure can be found. The figures have been deflated to 1871 prices by a deflator for public consumption developed by Krantz and Nilsson (1975).

Taxes on capital and labor incomes were set to the same value in the base run of the model. The magnitude of the Swedish taxes in the 19th century is discussed in Lundsjö (1975). He indicates a tax rate of roughly 5-6 percent. The tax parameters τ^l and τ^r were set to 6.2 percent. At this rate total government income is equal to total government expenditure.

B.9 Net Capital Inflow and Remittances

Net capital inflow, F, is determined outside the model. The data were taken from Krantz and Nilsson (1975:154). They also constructed the price deflator that has been used.

There exist data on remittances from previous emigrants to Sweden (Lindahl, Dahlgren, and Koch 1937:588) from 1885 onwards. These figures have been used when solving the model for 1885 and later. The capital flow, F, has to be adjusted when including remittances. The capital inflow plus remittances make up the exogenously determined saldo of the balance of current account. Therefore, when including remittances, the amount of remittances has to be deducted from the values for F.

B.10 Savings

There are three different sources of savings in the model: foreign savings, government savings, and private savings. Foreign saving is exogenously determined. Government saving is the difference between its income (taxes) and its expenditure. Private savings are determined by capitalists' and laborers' savings. The share of income that will be saved, s^c, s^l, was determined exogenously. We have assumed that capitalists save at a higher rate than the labor force. When calibrating the model, s^l was set so that the sum of savings from the three different sources was equal to actual savings that year. The savings parameters were set to 7.65 percent (s^l) and 12 percent (s^c).

Investment was allocated between urban and rural sectors endogenously. It was assumed that 80 percent of the savings in the urban and rural sectors were reinvested in the same sector. The remaining private savings were allocated between rural and urban investments by the relative rate of return on capital between these sectors.

Investment goods are produced in two sectors in the model, the export-oriented sector and the sector of building and construction. The allocation between them was made exogenously. The share of buildings and construction in total investments, ξ, is taken from Johansson (1967, Table 47).

B.11 Domestic Prices

Very disaggregated price data exist for the entire period (Krantz and Nilsson 1975). Different price series have been aggregated to match the sectors of the model. The sectoral weights which are used in the study by Krantz and Nilsson have been applied when aggregating the price data. The sectoral prices we have used consist of the following price series.

The price of agricultural output was taken directly from Krantz and Nilsson. Prices for the export-oriented sector are an aggregation of the prices in the metal industry and wood products industry. The prices of the food processing, textile, and leather industries contribute to the price of the homemarket sector. The price of the service sector is made up of price series for transport and communication, personal private services (which include trade, hotels and restaurants, professional services, and domestic services), public administration, and housing. Krantz and Nilsson have also published price data on building and construction activities. The relative prices for the benchmark years are displayed in Table 13.

Table 13. Sectoral relative prices 1871-1910

	Sector				
Year	1	2	3	4	5
1871	100.0	100.0	100.0	100.0	100.0
1880	106.0	105.4	106.6	104.1	105.1
1890	95.2	89.8	98.5	105.8	103.1
1900	118.4	101.1	101.8	120.4	114.3
1910	126.1	80.0	110.5	135.1	125.0

B.12 World Market Prices

There are three world market prices in the model, one for each of the sectors participating in foreign trade. Because of the assumption that Sweden is a small and open economy and thus an exporter unable to influence world market prices, these should be exogenous. A price index of agricultural goods (P_1^W) was constructed using data on quantity and value on Swedish agricultural export published in Historical Statistics of Sweden (1969, part 3, Tables 3.2 and 4.4). It is impossible to use the data on foreign trade for the other two series of world market prices (P_2^W and P_3^W) because quantities and values do not correspond. Other sources have been used.

World market prices between 1865 and 1913 are published for different commodities in a recent study by Lewis (1978). Lewis' data have been used for the remaining world market prices in the model. Prices of manufactures were assumed to approximate exports of sector 2 and prices on cotton and coffee imports of sector 3 (Lewis 1978:280-281). P_1^W and P_2^W were recalculated relative to P_2^W because the world market price of sector 2 completely determines the domestic price of that sector. This price is used as a numeraire in the model. All prices are unity in the base year. Three-year moving averages have been used instead of annual data. The figures are displayed in Table 14.

Table 14. World market prices 1971-1890

	Sector	
Year	1	3
1871	1.0	1.0
72	0.995	1.0654
73	1.099	1.1278
74	1.215	1.1337
75	1.312	1.1981
76	1.269	1.1091
77	1.266	1.0800
78	1.234	1.0869
79	1.257	1.0638
80	1.254	1.0397
81	1.222	0.9687
82	1.164	0.8948
83	1.139	0.8911
84	1.175	0.8944
85	1.2090	0.9246
86	1.1490	1.0224
87	1.0970	1.1600
88	1.0500	1.2897
89	1.1740	1.3050
90	1.2200	1.3200

B.13 Migration

Rural-to-urban migration and emigration was determined in two steps. First the total outmigration (O) as a share of rural population (N_A) is determined, followed by the share of emigrants (E) in total migrants:

$$O/N_A = m1 - m2W_A + m3W_2 + m4B_{US}$$

$$E/O = m5 + m6W_{US}/W_2 + m7B_{US}$$

Figures on agricultural real wage in the U.S. were taken from Phelps-Brown (1968) and the index of industrial activities B_{US} from Frickey (1942). Because no time series exist on internal migration we have not been able to estimate the migration functions. The parameters were assigned the following values: m1 = 0.0235, m2 = 0.019, m3 = 0.0445, m4 = 0.0205, m5 = 0.9268, m6 = 0.0859, m7 = 1.062.

NOTES

1) Deliveries from the different sectors to agriculture are found in Johansson (1967) Table 3, the service sector in Tables 31, 35, 39, and 41 and to building and construction in Table 28.

2) As has been suggested by Krantz and Nilsson (1975:28) Johansson's balancing item "changes in stocks" (Johansson, Table 3) has been added to intermediate deliveries to the manufacturing industry.

3) This has been calculated before trade markups are added to gross output.

4) Investment table 45, consumption (public and private) table 43, and export table 49.

APPENDIX C
SIMULATION RESULTS

Table C.1 The base solution 1871

P_1	0.9987	D_{1A}	183.9400
P_3	1.0000	D_{2A}	4.8630
P_4	1.0011	D_{3A}	96.9470
P_5	1.0010	D_{4A}	58.0360
P_1^D	0.9988	D_{1U}	123.1700
P_3^D	1.0000	D_{2U}	12.0930
P_4^D	1.0011	D_{3U}	241.1200
P_5^D	1.0010	D_{4U}	114.9000
P_1^*	0.6444	Z_1	52.1730
P_2^*	0.3791	Z_2	92.0960
P_3^*	0.1509	Z_3	15.0000
P_4^*	0.8969	Z_4	28.0470
P_5^*	0.8592	M_1	50.3050
X_1	601.0200	M_2	15.9840
X_2	161.0300	M_3	115.0200
X_3	325.0500	S_1	19.6370

(cont.)

Table C.1 (cont.)

X_4	442.0500	S_U	52.2950
X_5	84.8750	S	71.8920
W_1	0.2575	I	71.8870
C_1	0.3130	O	46.9030
W_U	1.0000	E	20.1810
C_U	1.0004	GNP	966.8500
L_2	98.2190	GNP per capita	0.2300
L_3	80.3200	wage share in agriculture	0.5274
L_4	242.3000	wage share in urban sectors	0.4885
L_5	84.3690	N_1	3043.8000
K_2	109.0200	N_U	1160.4000
K_3	58.6030	K_1	1423.0000
K_4	1553.0000	K_U	1730.6000
K_5	9.9856		
$Y_A^{\ell} + Y_A^{c}$	343.6200		
$Y_U^{\ell} + Y_U^{c}$	491.2500		

Table C.2 Counterfactual simulations: Agriculture experiments
Change in percent compared with the base solution

	N_A+6.92%	N_A+6.92% R_1+10%	N_A+6.92% h_1+10%	N_A+6.92% R_1+10% h_1+10%	N_A+3.5% N_U+9.1%
P_1	- 5.4	- 8.7	- 16.0	- 18.6	2.9
P_3	- 0.3	- 0.4	- 0.7	- 0.7	2.6
P_4	4.0	6.4	12.0	14.2	4.5
P_5	2.4	3.8	7.0	8.2	- 0.9
P_1^D	- 5.0	- 8.0	- 14.8	- 17.2	2.6
P_3^D	- 0.2	- 0.3	- 0.5	- 0.5	.8
P_4^D	4.0	6.4	12.0	14.2	4.5
P_5^D	2.4	3.8	7.0	8.2	- 0.9
P_1^*	- 7.5	- 18.7	- 22.1	- 25.8	2.8
P_2^*	2.6	4.2	7.6	8.8	- 3.8
P_3^*	3.2	5.1	9.5	11.1	0.8
P_4^*	4.2	6.8	12.8	15.0	4.9
P_5^*	2.6	4.2	7.7	8.9	- 1.3
X_1	4.8	6.8	11.9	14.1	2.4

(cont.)

Table C.2 (cont.)

	N_A+6.92%	N_A+6.92% R_1+10%	N_A+6.92% h_1+10%	N_A+6.92% R_1+10% h_1+10%	N_A+3.5% N_U+9.1%
X_2	- 3.9	- 6.5	- 13.2	- 16.0	11.8
X_3	1.2	2.2	4.5	5.4	- 0.4
X_4	0.5	0.9	1.7	2.1	1.8
X_5	- 1.2	- 2.0	- 3.5	- 4.0	6.9
W_1	- 9.9	- 12.7	- 19.6	- 21.9	1.4
C_1	- 6.8	- 9.7	- 14.9	- 22.9	3.2
W_U	2.6	4.2	7.5	8.7	- 6.0
C_U	2.8	4.5	8.4	9.9	10.4
L_2	- 3.9	- 6.5	- 13.2	- 15.9	13.3
L_3	1.5	2.8	5.6	6.7	3.8
L_4	1.5	2.4	4.7	5.6	8.7
L_5	- 1.2	- 2.0	- 3.4	- 3.9	10.1
K_2	- 3.9	- 6.5	- 13.3	- 16.1	5.7
K_3	0.8	1.6	3.3	3.8	- 4.8
K_4	0.3	0.4	0.8	1.0	- 0.2
K_5	- 1.2	- 2.0	- 3.7	- 4.3	0.2

(cont.)

Table C.2 (cont.)

	N_A+6.92%	N_A+6.92% R_1+10%	N_A+6.92% h_1+10%	N_A+6.92% R_1+10% h_1+10%	N_A+3.5% N_U+9.1%
$Y_A^{\ell} + Y_A^c$	- 2.9	- 5.9	- 12.7	- 15.2	5.3
$Y_U^{\ell} + Y_U^c$	3.6	5.7	10.7	12.6	6.2
D_{1A}	4.9	4.4	3.3	2.8	3.2
D_{2A}	- 8.4	- 11.7	- 19.4	- 22.2	2.2
D_{3A}	- 8.4	- 11.7	- 19.5	- 22.4	1.8
D_{4A}	- 5.0	- 7.6	- 13.1	- 15.0	1.7
D_{1U}	4.9	8.2	16.3	19.6	5.8
D_{2U}	4.7	7.6	14.2	16.7	5.0
D_{3U}	4.9	7.9	14.7	17.3	3.3
D_{4U}	1.1	1.7	3.0	3.5	1.4
Z_1	15.0	25.6	54.5	67.3	- 6.9
Z_2	- 6.6	- 11.2	- 22.8	- 27.5	16.4
Z_3	0.5	0.8	1.3	1.3	- 5.0
Z_4	1.1	2.0	4.8	6.2	6.8
M_1	- 0.2	- 1.5	- 4.5	- 5.6	5.4
M_2	- 0.2	- 0.2	- 0.4	- 0.5	5.5

(cont.)

Table C.2 (cont.)

	N_A+6.92%	N_A+6.92% R_1+10%	N_A+6.92% h_1+10%	N_A+6.92% R_1+10% h_1+10%	N_A+3.5% N_U+9.9%
M_3	0.04	0.5	1.6	2.1	12.0
S_1	- 6.5	- 9.3	- 15.4	- 17.8	4.6
S_U	4.8	7.8	14.6	17.2	6.0
I	- 0.5	- 0.9	- 1.5	- 1.8	9.3
O	15.3	19.4	28.8	32.2	- 7.1
E	13.0	15.8	21.9	24.0	- 3.1
GNP	1.3	1.6	2.4	2.7	5.4
GNP per capita	- 3.7	- 3.4	- 2.6	- 2.3	0.4

Table C.3 Counterfactual simulations:
Higher world market price on agricultural goods.
Change in percent compared with base run in 1890

P_1	1.4	D_{1A}	1.7
P_3	- 0.5	D_{2A}	3.1
P_4	- 5.8	D_{3A}	3.3
P_5	- 2.8	D_{4A}	7.8
P_1^D	2.7	D_{1U}	- 4.4
P_3^D	- 0.4	D_{2U}	- 6.2
P_4^D	- 5.8	D_{3U}	- 5.7
P_5^D	- 2.8	D_{4U}	- 1.1
P_1^*	1.7	Z_1	42.6
P_2^*	- 2.6	Z_2	-20.6
P_3^*	- 4.1	Z_3	1.0
P_4^*	- 6.3	Z_4	- 4.7
P_5^*	- 3.1	M_1	- 9.9
X_1	1.5	M_2	- 1.7
X_2	- 9.7	M_3	- 3.7
X_3	- 1.3	S_1	2.7

(cont.)

Table C.3 (cont.)

X_4	0.7	S_U	- 6.3
X_5	1.8	I	- 0.6
W_1	1.3	O	- 2.6
W_U	- 2.2	E	- 1.5
C_1	1.4	GNP	- 0.2
C_U	- 6.1	GNP per capita	- 0.6
L_2	- 9.9	wage share in agriculture	- 1.6
L_3	- 2.5	wage share in urban sectors	4.9
L_4	- 1.9	N	0.4
L_5	1.3	N_1	1.9
K_2	- 8.9	N_U	- 2.0
K_3	0.3	K_1	1.6
K_4	1.6	K_U	1.2
K_5	3.5		
$Y_A^{\ell} + Y_A^c$	3.2		
$Y_U^{\ell} + Y_U^c$	- 5.0		

Table C.4 Counterfactual simulations: No emigration
Change in percent compared with the base run in 1880 and 1890, respectively

	No emigration		No emigration and lower productivity in agriculture
	1880	1890	1880
P_1	- 3.2	- 3.8	5.0
P_3	0.9	0.8	- 0.2
P_4	3.9	9.2	- 5.6
P_5	1.8	2.7	- 3.2
P_1^D	- 2.4	- 3.2	4.5
P_3^D	0	0.8	- 0.1
P_4^D	3.9	9.2	- 5.6
P_5^D	1.8	2.7	- 3.2
P_1^*	- 4.7	- 5.3	6.8
P_2^*	0	5.0	- 3.3
P_3^*	0	6.7	- 4.3
P_4^*	4.4	9.2	- 5.9
P_5^*	2.1	3.1	- 3.5
X_1	2.8	7.1	- 2.0

(cont.)

Table C.4 (cont.)

	No emigration		No emigration and lower productivity in agriculture
	1880	1890	1880
M_3	1.5	8.2	- 3.4
S_1	- 2.7	0.3	1.9
S_U	3.9	11.3	- 6.5
I	0.7	5.0	- 1.2
O	13.0	43.3	- 7.8
GNP	1.4	6.0	- 1.3
GNP per capita	- 1.6	- 2.2	- 4.1
wage share in agriculture	- 1.9	- 1.8	0.8
wage share in urban sectors	- 1.9	- 5.2	4.1
N	3.0	8.4	2.9
N_1	4.2	10.4	4.9
N_U	0.4	5.4	- 1.0
K_1	- 0.3	- 4.8	0.1
K_U	- 0.2	0.6	0.2

Table C.4 Counterfactual simulations: No emigration
Change in percent compared with the base run in 1880 and 1890, respectively

	No emigration		No emigration and lower productivity in agriculture
	1880	1890	1880
P_1	- 3.2	- 3.8	5.0
P_3	0.9	0.8	- 0.2
P_4	3.9	9.2	- 5.6
P_5	1.8	2.7	- 3.2
P_1^D	- 2.4	- 3.2	4.5
P_3^D	0	0.8	- 0.1
P_4^D	3.9	9.2	- 5.6
P_5^D	1.8	2.7	- 3.2
P_1^*	- 4.7	- 5.3	6.8
P_2^*	0	5.0	- 3.3
P_3^*	0	6.7	- 4.3
P_4^*	4.4	9.2	- 5.9
P_5^*	2.1	3.1	- 3.5
X_1	2.8	7.1	- 2.0

(cont.)

Table C.4 (cont.)

	No emigration		No emigration and lower productivity in agriculture
	1880	1890	1880
X_2	- 0.8	6.9	0.7
X_3	0.7	3.7	- 2.4
X_4	1.6	1.9	- 0.4
X_5	- 0.7	2.0	1.4
W_1	- 5.1	- 9.4	- 0.4
C_1	- 3.5	- 3.6	3.2
W_U	1.7	2.2	- 3.2
C_U	3.2	8.7	- 4.4
L_2	- 0.7	7.5	0.6
L_3	1.2	5.8	- 3.1
L_4	1.2	6.2	- 2.1
L_5	- 0.6	3.1	1.2
K_2	- 1.0	4.7	0.9
K_3	0.2	0.8	- 1.6
K_4	- 0.2	0.4	0.1
K_5	- 1.0	- 1.1	1.8

(cont.)

Table C.4 (cont.)

	No emigration		No emigration and lower productivity in agriculture
	1880	1890	1880
$Y_A^\ell + Y_A^c$	- 1.3	1.9	4.8
$Y_U^\ell + Y_U^c$	3.0	9.4	- 5.1
D_{1A}	3.0	8.1	3.9
D_{2A}	- 4.2	- 1.1	2.2
D_{3A}	- 3.5	- 1.2	2.4
D_{4A}	- 3.8	- 6.0	5.5
D_{1U}	3.3	8.8	- 5.3
D_{2U}	3.9	10.8	- 6.5
D_{3U}	3.7	10.0	- 6.3
D_{4U}	0.7	3.5	- 1.5
Z_1	7.8	9.5	- 11.4
Z_2	- 1.6	9.8	2.1
Z_3	- 0.2	- 1.9	0.4
Z_4	1.0	7.4	- 1.8
M_1	2.3	4.3	2.3
M_2	0.5	4.7	- 1.4

(cont.)

Table C.4 (cont.)

	No emigration		No emigration and lower productivity in agriculture
	1880	1890	1880
M_3	1.5	8.2	- 3.4
S_1	- 2.7	0.3	1.9
S_U	3.9	11.3	- 6.5
I	0.7	5.0	- 1.2
O	13.0	43.3	- 7.8
GNP	1.4	6.0	- 1.3
GNP per capita	- 1.6	- 2.2	- 4.1
wage share in agriculture	- 1.9	- 1.8	0.8
wage share in urban sectors	- 1.9	- 5.2	4.1
N	3.0	8.4	2.9
N_1	4.2	10.4	4.9
N_U	0.4	5.4	- 1.0
K_1	- 0.3	- 4.8	0.1
K_U	- 0.2	0.6	0.2

APPENDIX D
THE EQUATION SYSTEM OF THE LINEAR MODEL

In this appendix our CGE model is reduced to 35 equations and linearized. Equations in the linearized version of the model are denoted by L.

Equations L.1 - L.5

The first 5 equations are derived from equations (37)-(41). The equation numbers correspond to Appendix A. We treat the variables as functions of time and differentiate at the base year. Some variables, such as prices and the efficiency variables in the production function, are equal to unity.

$$P_i = P_i^W = P_i^D = 1 \qquad i = 1,\dots,5$$

$$h_i = g_i = 1 \qquad i = 1,\dots,5$$

Moreover, in the model the world market price expressed in Swedish currency on commodity no. 2 is the numeraire and we can therefore disregard P_2^W.

Differentiation of equation (37) now yields

$$W_1 + L_1(1+\rho_1) = \rho_1(\dot{H}_1-\dot{h}_1) + \dot{X}_1 + \dot{P}_1^* \qquad (D.1)$$

The notation $(\dot{X})$ is an abbreviation for the relative growth rate $\frac{dX}{dt}/X$. We can then substitute for $\dot{H}_1$ and $\dot{P}_1^*$. Equation (2) is differentiated with respect to time and yields:

$$\dot{H}_1 = k_1(\dot{K}_1 + \dot{g}_1) + l_1(\dot{L}_1 + \dot{h}_1) \qquad (D.2)$$

where

$$k_1 = \frac{\delta_1 K_1^{-\rho_1}}{\delta_1 K_1^{-\rho_1} + \gamma_1 L_1^{-\rho_1}}$$

$$l_1 = \frac{\gamma_1 L_1^{-\rho_1}}{\delta_1 K_1^{-\rho_1} + \gamma_1 L_1^{-\rho_1}}$$

To substitute for $\dot{P}_i^*$ we use equations (32)-(36). Before differentiating we insert equations (79)-(84) into these equations to remove P_i^D. We define

$$im_j \equiv \frac{M_j}{X_j - Z_j} = \bar{M}_j \left(\frac{P_j}{P_j^W}\right)^{\mu_j} \qquad j = 1,3$$

and insert also equations (85)-(86). Differentiation yields

$$\dot{P}_i^* = \frac{1}{P_i^*}\left[\dot{P}_i - \sum_{j=1,3} \frac{a_{ji}}{(1+im_j)}\left(\dot{P}_j + im_j \dot{P}_j^W\right) - \right.$$

$$\left. - \sum_{j=2,4,5} a_{ji}\dot{P}_j\right] \qquad i = 1,\dots,5 \qquad \text{(D.3)}$$

Inserting (D.2) and (D.3) into (D.1) and using equation (42) we obtain

$$\dot{W}_1 - \dot{X}_1 - \frac{1}{P_1^*}\left[\left(1 - \frac{a_{11}}{1+im_1}\right)\dot{P}_1 - \frac{a_{31}}{1+im_3}\dot{P}_3 - a_{41}\dot{P}_4 - a_{51}\dot{P}_5\right] =$$

$$= \rho_1 k_1(\dot{g}_1 + \dot{K}_A) - \rho_1(1-l_1)\dot{h}_1 - (1 - \rho_1 l_1 + \rho_1)\dot{N}_A -$$

$$- \frac{1}{P_1^*}\left[\frac{im_1}{1+im_1} a_{11} \dot{P}_1^W - \frac{im_3}{1+im_3} a_{31} \dot{P}_3^W\right] \qquad \text{(L.1)}$$

The differentiation is straightforward for equations (38)-(41). We obtain

$$\dot{W}_i + (1-\rho_i)(\dot{L}_i-\dot{X}_i) + \rho_i\dot{h}_i - \dot{P}^*_i = 0$$

$$i = 2,...,5 \qquad (D.4)$$

Equations (49)-(52) are differentiated and inserted in (D.4) and we also substitute for P* using (D.3). These substitutions result in the following equations:

$$\dot{W}_U + (1+\rho_3)(\dot{L}_3-\dot{X}_3) - \frac{1}{P^*_3}\left[\left(1 - \frac{a_{33}}{1+im_3}\right)\dot{P}_3 - \right.$$

$$\left. - \frac{a_{13}}{1+im_3}\dot{P}_1 - a_{43}\dot{P}_4 - a_{53}\dot{P}_5\right] =$$

$$= -\rho_3\dot{h}_3 - \frac{a_{33}}{P^*_3}\frac{im_3}{1+im_3}\dot{P}^W_3 - \frac{a_{13}}{P^*_3}\frac{im_3}{1+im_3}\dot{P}^W_1 \qquad (L.2)$$

$$\dot{W}_U + (1+\rho_2)(\dot{L}_2-\dot{X}_2) + \frac{1}{P^*_2}\frac{a_{12}}{1+im_1}\dot{P}_1 +$$

$$+ \frac{1}{P^*_2}\left(\frac{a_{32}}{1+im_3}\dot{P}_3 + a_{42}\dot{P}_4 + a_{52}\dot{P}_5\right) =$$

$$= - \frac{a_{12}}{P^*_2}\frac{im_1}{1+im_1}\dot{P}^W_1 - \frac{a_{32}}{P^*_2}\frac{im_3}{1+im_3}\dot{P}^W_3 - \rho_2\dot{h}_2 \qquad (L.3)$$

$$\dot{W}_U + (1+\rho_4)(\dot{L}_4-\dot{X}_4) - \frac{1}{P^*_4}(1-a_{44})\dot{P}_4 +$$

$$+ \frac{a_{14}}{P^*_4}\frac{1}{1+im_1}\dot{P}_1 + \frac{a_{34}}{P^*_4}\frac{1}{1+im_3}a_{34}\dot{P}_3 + \frac{a_{54}}{P^*_4}\dot{P}_5 =$$

$$= - \frac{a_{14}}{P^*_4}\frac{im_1}{1+im_1}\dot{P}^W_1 - \frac{a_{34}}{P^*_4}\frac{im_3}{1+im_3}\dot{P}^W_3 - \rho_4\dot{h}_4 \qquad (L.4)$$

$$\dot{W}_U + (1+\rho_5)(\dot{L}_5-\dot{X}_5) - \frac{1}{P_5^*}(1-a_{55})\dot{P}_5 +$$

$$+ \frac{a_{15}}{P_5^*}\frac{1}{1+im_1}\dot{P}_1 + \frac{a_{35}}{P_5^*}\frac{1}{1+im_3}\dot{P}_3 + \frac{a_{45}}{P_5^*}\dot{P}_4 =$$

$$= - \frac{a_{15}}{P_5^*}\frac{im_1}{1+im_1}\dot{P}_1^W - \frac{a_{35}}{P_5^*}\frac{im_3}{1+im_3}\dot{P}_3^W - \frac{a_{25}}{P_5^*}\dot{P}_2^W - \rho_5\dot{h}_5 \quad (L.5)$$

Equations L.6 - L.10

The second group of equations are derived from the first order condition for capital, equations (44)-(48). Starting with agriculture, differentiation of equation (44) yields

$$\dot{C}_1 + (1+\rho_1)\dot{K}_A = \rho_1(\dot{H}_1-\dot{g}_1) + \dot{X}_1 + \dot{P}_1^*$$

We insert equations (D.2), (D.3) and (42) and obtain

$$\dot{C}_1 - \dot{X}_1 - \frac{1}{P_1^*}\left[\left(1 - \frac{a_{11}}{1+im_1}\right)\dot{P}_1 - \frac{a_{31}}{i+im_3}\dot{P}_3 - a_{41}\dot{P}_4 - a_{51}\dot{P}_5\right] =$$

$$= \rho_1 l_1(\dot{N}_A+\dot{h}_1) + (k_1-1)\rho_1\dot{g}_1 - (1-\rho_1 k_1+\rho_1)\dot{K}_A -$$

$$- \frac{1}{P_1^*}\left[\frac{im_1}{1+im_1} a_{11}\dot{P}_1^W + \frac{im_3}{1+im_3} a_{31}\dot{P}_3^W\right] \quad (L.6)$$

Turning to the urban sectors, equations (45)-(48) are differentiated and equations (D.4) and (49)-(52) inserted instead of P_i^* and W_i to get a less complicated expression

$$\dot{Q}_i + (1+\rho_i)(\dot{K}_i-\dot{L}_i) + \rho_i(\dot{g}_i-\dot{h}_i) - \dot{W}_U = 0 \quad i = 2,\ldots,5$$

Using equations (53)-(56) and (57)-(60) we can substitute for $\dot{Q}_i$ and obtain

$$\sigma_i/Q_i \ \dot{C}_U + \frac{(\iota_i+\sigma_i)\Phi_i}{Q_i} \dot{P}_5 + (1+\rho_i(\dot{K}_i-\dot{L}_i) - \dot{W}_U =$$

$$= \rho_i(\dot{h}_i-\dot{g}_i) \qquad i = 2,\ldots,5 \qquad \text{(L.7-L.10)}$$

Equations L.11 - L.15

Differentiations of the production functions are straightforward (equations (1)-(6)) and yield the following equations. Remember that all technical coefficients (g_i, h_i) are unity in the base year. Equations (2) and (42) are inserted in (1).

$$\dot{X}_1 = R_1^{-\alpha\rho_1} k_1 \dot{K}_A + R_1^{-\alpha\rho_1} l_1 \dot{N}_A + \alpha R_1^{-\alpha\rho_1} \dot{R}_1 +$$

$$+ R_1^{-\alpha\rho_1} k_1 \dot{g}_1 + R_1^{-\alpha\rho_1} l_1\dot{h}_1 \qquad \text{(L.11)}$$

$$\dot{X}_i - k_i\dot{K}_i - l_i\dot{L}_i = k_i\dot{g}_i + l_i\dot{h}_i$$

$$i = 2,\ldots,5 \qquad \text{(L.12-L.15)}$$

where

$$k_i = \frac{\delta_i K_i^{-\rho_i}}{\delta_i K_i^{-\rho_i} + \gamma_i L_i^{-\rho_i}}$$

$$l_i = \frac{\gamma_i L_i^{-\rho_i}}{\delta_i K_i^{-\rho_i} + \gamma_i L_i^{-\rho_i}} \qquad i = 1,\ldots,5$$

Equation L.16

Turning to the demand side of the model, we first have to define disposable income used for consumption. In the static model we defined one demand system for the rural region and one for the urban region. In this linear version of our model, we do not make this distinction. Only one set of demand equations is specified. This is also consistent with the base solution for the static model. In that case we use the same values for the parameters in the demand equations for urban and rural regions.

Disposable income from labor Y^{ℓ} and capital Y^{c} in the two regions are summed, equations (65)-(68):

$$Y = Y_A^{\ell} + Y_U^{\ell} + Y_A^{c} + Y_U^{c}$$

Equations (69)-(78) are inserted into this equation. In the base year remittances (T) are zero and are thus excluded. As in previous cases we use equations (2) and (42). Differentiation with respect to time and substitution of P_i^D yields the following equation:

$$\begin{aligned}
Y\dot{Y} &- (\ell-c)W_1L_1\dot{W}_1 - cP_1^*X_1\dot{X}_1 - \\
&- \left[s^{\ell}b_1N\left(\frac{1}{1+im_1}\right) + cX_1\left(1 - \frac{a_{11}}{1+im_1}\right)\right]\dot{P}_1 + \\
&+ \left[s^{\ell}b_3N\left(\frac{1}{1+im_3}\right) + cX_1\left(\frac{a_{31}}{1+im_3}\right)\right]\dot{P}_3 + \left(s^{\ell}b_4N + cX_1a_{41}\right)\dot{P}_4 + \\
&+ c\left[X_1a_{51} - \sum_{i=2}^{5} K_i(\iota_i+\sigma_i)\Phi_i\right]\dot{P}_5 - \ell\sum_{i=2}^{5}\omega_iL_i\dot{L}_i - \\
&- \ell\sum_{i=2}^{5}\omega_iL_i\dot{W}_U - c\sum_{i=2}^{5}\sigma_iK_i\dot{K}_i - c\sum_{i=2}^{5}\sigma_iK_i\dot{C}_U = \\
&= \left[(\ell-c)p_1W_1L_1 + s^{\ell}N_A\sum_{i=1}^{4} b_i\right]\dot{N}_A + \\
&+ \left(s^{\ell}b_1N - ca_{11}X_1\right)\frac{im_1}{1+im_1}\dot{P}_1^W + \\
&+ \left(s^{\ell}b_3N - ca_{31}X_1\right)\frac{im_3}{1+im_3}\dot{P}_3^W + s^{\ell}N_U\sum_{i=1}^{4} b_i\dot{N}_U \qquad \text{(L.16)}
\end{aligned}$$

where $\ell = (1-\tau^{\ell})(1-s^{\ell})$
$c = (1-\tau^{c})(1-s^{c})$

Equations L.17 - L.20

Differentiation of the linear expenditure system (equations (69)-(78)) gives the following result. We have summed disposable income and substituted for P_i^D. Looking at the input-output table for 1871 (see Appendix B) one can see that there is no private demand for the output of sector 5. Therefore, that equation can be excluded.

$$D_1\dot{D}_1 + (D_1-b_1N+\beta_1b_1N)\frac{1}{1+im_1}\dot{P}_1 - \beta_1Y\dot{Y} + \beta_1b_3N\frac{1}{1+im_3}\dot{P}_3 + $$

$$+ \beta_1b_4N\dot{P}_4 = (b_1N-D_1-\beta_1b_1N)\frac{im_1}{1+im_1}\dot{P}_1^W -$$

$$- \beta_1b_3N\frac{im_3}{1+im_3}\dot{P}_3^W + \left(b_1 - \beta_1\sum_{i=1}^{4} b_i\right)N_A\dot{N}_A +$$

$$+ \left(b_1 - \beta_1\sum_{i=1}^{4} b_i\right)N_U\dot{N}_U \qquad \text{(L.17)}$$

$$D_2\dot{D}_2 + \beta_2b_1N\frac{1}{1+im_1}\dot{P}_1 - \beta_2Y\dot{Y} + \beta_2b_3N\frac{1}{1+im_3}\dot{P}_3 +$$

$$+ \beta_2b_4N\dot{P}_4 = \left(b_2 - \beta_2\sum_{i=1}^{4} b_i\right)N_A\dot{N}_A +$$

$$+ \left(b_2 - \beta_2\sum_{i=1}^{4} b_i\right)N_U\dot{N}_U - \beta_2b_1N\frac{im_1}{1+im_1}\dot{P}_1^W -$$

$$- \beta_2b_3N\frac{im_3}{1+im_3}\dot{P}_3^W \qquad \text{(L.18)}$$

$$D_3\dot{D}_3 - \beta_3 Y\dot{Y} + \beta_3 b_1 N \frac{1}{1+im_1} \dot{P}_1 + (D_3 - b_3 N + \beta_3 b_3 N) \frac{1}{1+im_3} \dot{P}_3 +$$

$$+ \beta_3 b_4 N\dot{P}_4 = \left(b_3 - \beta_3 \sum_{i=1}^{4} b_i\right) N_A \dot{N}_A +$$

$$+ \left(b_3 - \beta_3 \sum_{i=1}^{4} b_i\right) N_U \dot{N}_U - \beta_3 b_1 N \frac{im_1}{1+im_1} \dot{P}_1^W +$$

$$+ (b_3 N - D_3 - \beta_3 b_3 N) \frac{im_3}{1+im_3} \dot{P}_3^W \qquad \text{(L.19)}$$

$$D_4\dot{D}_4 - \beta_4 Y\dot{Y} + (D_4 + \beta_4 b_4 N - b_4 N) P_4 + \beta_4 b_1 N \frac{1}{1+im_1} \dot{P}_1 +$$

$$+ \beta_4 b_3 N \frac{1}{1+im_3} \dot{P}_3 = \left(b_4 - \beta_4 \sum_{i=1}^{4} b_i\right) N_A \dot{N}_A +$$

$$+ \left(b_4 - \beta_4 \sum_{i=1}^{4} b_i\right) \dot{N}_U - \beta_4 b_1 N \frac{im_1}{1+im_1} \dot{P}_1^W - \beta_4 b_3 N \frac{im_3}{1+im_3} \dot{P}_3^W$$

$$\text{(L.20)}$$

<u>Equations L.21 - L.27</u>

These equations concern exports and imports in the various sectors. Differentiation is straightforward using equations (85)-(90) and yields the following results. Remember that $P_i/PW_i = 1$ in the base year.

$$\dot{M}_i - \mu_i P_i - \frac{X_i}{(X_i - Z_i)} \dot{X}_i + \frac{Z_i}{(X_i - Z_i)} \dot{Z}_i = \mu_i \dot{P}_i^W$$

$$i = 1, 3 \qquad \text{(L.21-L.22)}$$

$$\dot{M}_2 - \frac{X_2}{(X_2 - Z_2)} \dot{X}_2 + \frac{Z_2}{(X_2 - Z_2)} \dot{Z}_2 = 0 \qquad \text{(L.23)}$$

$$\dot{Z}_i - \varepsilon_i \dot{P}_i = - \varepsilon_i \dot{P}_i^W + \dot{V}_i \qquad i = 1, 3 \qquad \text{(L.24-L.25)}$$

$$\dot{Z}_4 - \frac{\nu}{Z_4} \sum_{i=1}^{3} Z_i \dot{Z}_i = 0 \qquad \text{(L.26)}$$

Differentiation of equation (91) yields

$$M_1 \dot{M}_1 + M_2 \dot{M}_2 + M_3 \dot{M}_3 - Z_1(\dot{Z}_1 + \dot{P}_1) - Z_2 \dot{Z}_2 -$$

$$- Z_3(\dot{Z}_3 + \dot{P}_3) - Z_4(\dot{Z}_4 + \dot{P}_4) =$$

$$= F\dot{F} - M_1 \dot{P}_1^W - M_3 \dot{P}_3^W \qquad \text{(L.27)}$$

Remember that all prices are unity in the base year and remittances (T) are zero in 1871.

Equations L.28 - L.29

To close the urban factor markets equations, (43) and (61) are used for the labor market and equation (62) for the market of capital goods.

$$\frac{L_2}{L_U} \dot{L}_2 - \frac{L_3}{L_U} \dot{L}_3 - \frac{L_4}{L_U} \dot{L}_4 + \frac{L_5}{L_U} \dot{L}_5 = \dot{N}_U \qquad \text{(L.28)}$$

$$\frac{K_2}{K_U} \dot{K}_2 + \frac{K_3}{K_U} \dot{K}_3 - \frac{K_4}{K_U} \dot{K}_4 + \frac{K_5}{K_U} \dot{K}_5 = \dot{K}_U \qquad \text{(L.29)}$$

Equations L.30 - L.34

To close the commodity markets we use equations (98)-(102). To substitute for I_2 and I_5 equations (96) and (97) are used and D_{ij} are summed. Differentiation yields

$$D_{iA} + D_{iU} = D_i \qquad i = 1,\ldots,5$$

$$(1-a_{11})X_1\dot{X}_1 - D_1\dot{D}_1 - a_{12}X_2\dot{X}_2 - a_{13}X_3\dot{X}_3 - a_{14}X_4\dot{X}_4 - $$

$$- a_{15}X_5\dot{X}_5 - Z_1\dot{Z}_1 + M_1\dot{M}_1 = 0 \qquad (L.30)$$

$$(1-a_{22})X_2\dot{X}_2 - D_2\dot{D}_2 - a_{21}X_1\dot{X}_1 - a_{23}X_3\dot{X}_3 - a_{24}X_4\dot{X}_4 - $$

$$- a_{25}X_5\dot{X}_5 - (1-\xi)I\dot{I} - Z_2\dot{Z}_2 + M_2\dot{M}_2 = 0 \qquad (L.31)$$

$$(1-a_{33})X_3\dot{X}_3 - D_3\dot{D}_3 - a_{31}X_1\dot{X}_1 - a_{32}X_2\dot{X}_2 - a_{34}X_4\dot{X}_4 - $$

$$- a_{35}X_5\dot{X}_5 - Z_3\dot{Z}_3 + M_3\dot{M}_3 = 0 \qquad (L.32)$$

$$(1-a_{44})X_4\dot{X}_4 - D_4\dot{D}_4 - a_{41}X_1\dot{X}_1 - a_{42}X_2\dot{X}_2 - a_{43}X_3\dot{X}_3 - $$

$$- a_{45}X_5\dot{X}_5 - Z_4\dot{Z}_4 = G\dot{G} \qquad (L.33)$$

$$(1-a_{55})X_5\dot{X}_5 - a_{51}X_1\dot{X}_1 - a_{52}X_2\dot{X}_2 - a_{53}X_3\dot{X}_3 - $$

$$- a_{54}X_4\dot{X}_4 - \xi I\dot{I} + \xi I\dot{P}_5 = 0 \qquad (L.34)$$

Equation 35

Differentiation of the GNP-equation (103) yields

$$GNP\ G\dot{N}P - \sum_{j=1}^{5}\left(X_j - \sum_{i=1}^{5} X_{ij}a_{ij}\right)\dot{X}_j - \left(X_1 - \sum_{j=1}^{5} X_{1j}\right)\frac{1}{1+im_1}\dot{P}_1 - $$

$$- \left(X_3 - \sum_{j=1}^{5} X_{3j}\right)\frac{1}{1+im_3}\dot{P}_3 - \left(X_4 - \sum_{j=1}^{5} X_{4j}\right)\dot{P}_4 - $$

$$- \left(X_5 - \sum_{j=1}^{5} X_{5j}\right)\dot{P}_5 = \left(X_1 - \sum_{j=1}^{5} X_{1j}\frac{im_1}{1+im_1}\right)\dot{P}_1^W + $$

$$+ \left(X_3 - \sum_{j=1}^{5} X_{3j}\right)\frac{im_3}{1+im_3}\dot{P}_3^W \qquad (L.35)$$

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