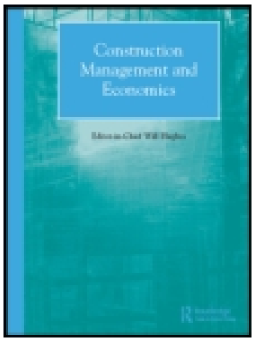

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Forecasting methodology of national demand for construction labour

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The paper presents a systematic methodology for forecasting the demand for construction labour in various skills, within a national economy. Major factors, which determine the future needs for dwelling units and for other types of construction, are discussed in detail, while the strengths and weaknesses of different forecasting approaches are highlighted. Possible sources, available in most countries, for statistical information, as well as the International Classification of Occupations and Economic Branches, are identified and evaluated. The methodology is general and may be applicable to any country. It is illustrated by an example of such a forecast for the next decade, performed by the authors in Israel, in the years 1988 and 1989. The various demand and supply parameters, which formed a basis for this forecast, significantly changed with the unexpected surge of immigration from the Soviet Union in 1990. The effects of this change are discussed separately in the paper.

Keywords: Building economics, forecasting, label statistics.

Introduction

Most construction industries around the world are characterized by unstable levels of activity. This inherent nature of the industry is usually held responsible for many problematic features pointed out in The Business Roundtable (1983). It causes, *inter alia,* severe fluctuations in manpower demands, which alternate between periods of severe shortage in construction workers and periods of unemployment.

This paper is the result of a study made by the authors for the Israeli Federation of Contractors and Builders, which sought a forecast of construction labour requirements during the decade, 1991–2000, as a basis for planning decisions involving recruitment of new workers, initiation of training programmes and investment in labour-saving technologies.

The study had three major objectives:

1. To estimate the demand for workers in major construction skills during the decade 1991–2000.
2. To assess the existing supply of such workers.
3. To compare demand and supply for each skill, derive conclusions and offer recommendations.

This paper focuses on the methodology adopted for the preparation of the labour demand forecast which is felt to be of greater interest to most readers than the specific Israeli case; however, some actual figures are included for illustration purposes. Those figures pertain to trends and estimates which prevailed prior to the significant political changes in the year 1990, which resulted in a tremendous surge of immigration to Israel. The effects of these changes are discussed separately.

General methodology

A conceptual model

Figure 1 presents the ingredients of the methodology applied to the attainment of the objectives mentioned above.

In order to operate this general model, it is necessary to establish, in advance, three bodies of data, each of which may be considered as an independent subproject:

Database #1: Expected physical quantities of yearly demand for each type of construction (e.g. square metres of residential buildings, public buildings, etc., kilometres of roads or cubic metres of concrete in heavy civil engineering projects).
Database #2: Typical labour-inputs per unit, for each

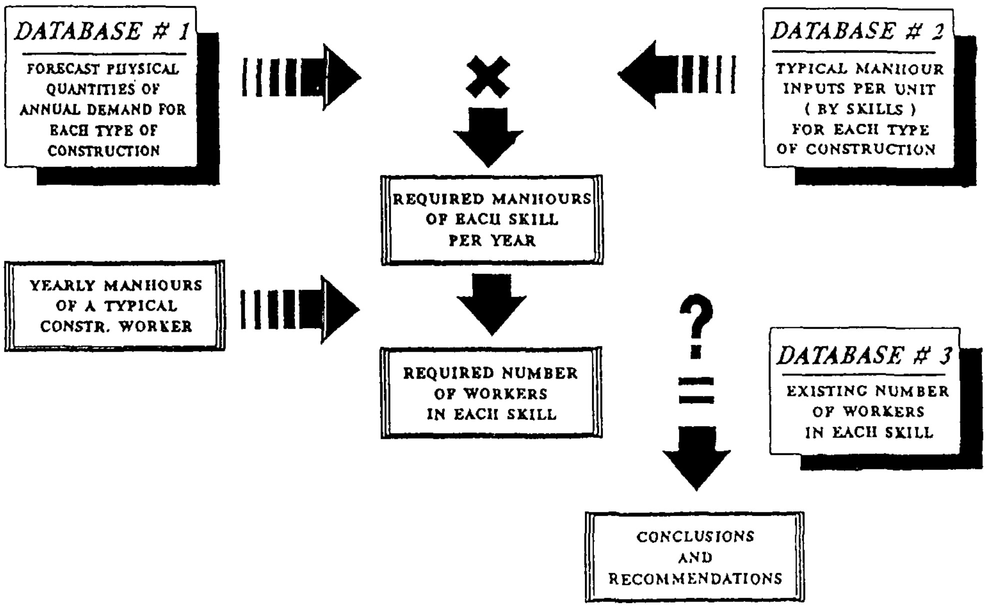

Figure 1 General methodology of the study

type of construction (e.g. manhours of different skills – carpenters, bricklayers, tile-setters, plumbers, painters, etc. – required for every square metre of residential buildings, public buildings, etc.).
Database #3: Supply of existing workers in each construction skill.

Mathematical formulation

Database #1 may be presented by a vector, Q, of physical yearly quantities (Q_i) of m types of construction, listed at a predetermined order. Database #2 may take the form of a matrix ((s)) which associates each entry (Q_i) in vector #1 with a list of n different construction skills, and provides specific values (s_{ij}) of required manhours of skill j per unit of construction type i. Once established, the cross multiplication of these two databases results in another vector, L, which presents total labour manhours required in each skill (L_j). Thus:

$$L_j = \sum_{i=1}^{m} Q_i \, s_{ij} \qquad (1)$$

where:

- i = Index label for type of construction (total of m types).
- j = Index label for type of skill (total of n types).
- L_j = Required **labour** manhours of each skill j.
- Q_i = Physical yearly **quantity** of construction type i.
- s_{ij} = Average or typical manhours of **skill** j, required to produce one unit (e.g. square metre) of construction type i.

The relationship among these variables are illustrated in Fig. 2.

Practical limitations

If all data exist, then the estimation of the demand for workers can be completed by 'translating' the required yearly manhours to required number of workers in each skill. Unfortunately, some parts of this model are merely theoretical, due to difficulties in obtaining information to create these two databases.

The composition of database #3, which seems to be a plain data collection gleaned from published labour statistics, also turned out to be quite complicated. Although such publications, in most countries, usually follow the International Labour Organization (ILO) recommendations, they still suffer from inaccuracy, ambiguity, and/or too generalized definitions of construction skills. Nevertheless, it is possible to overcome or bypass numerous obstacles and data gaps by reasoning and making logical assumptions, in order to arrive at a fairly realistic estimation of both demand and supply.

Most of the techniques applied in this study are explained in the following sections, starting with Table 1, which is an itemized list of major types of construction.

The feature common to the first two groups of data in Table 1, is that in most countries they are routinely measured and recorded – in physical units, such as square metres of floor area – by various agencies, since they usually require building permits from several authorities. These data, in turn, are reflected in detail in the national building statistics. Furthermore, the large

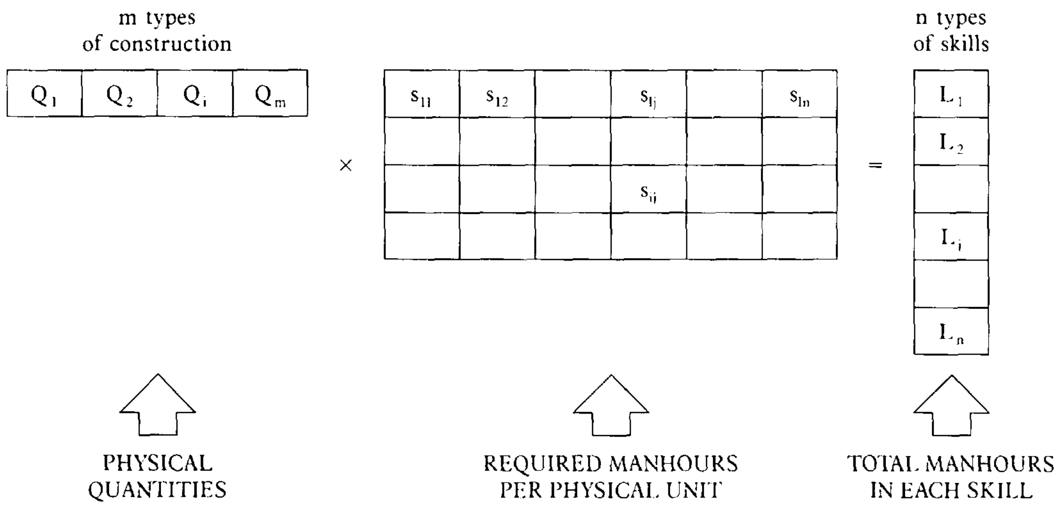

Figure 2 Schematic representation of demand estimate

Table 1 Major types of construction

1. Residential buildings	2. Non-residential buildings
1.1. New construction	2.1. Hotels, commercial and office
1.1.1. Conventional methods	2.2. Industry (heavy, light)
1.1.2. Prefabricated	2.3. Public buildings (incl. educational, health)
1.1.3. Industrialized on site	2.4. Farm buildings
1.2. Additions to existing buildings	2.5. Others
3. Construction for other purposes	4. Maintenance of existing buildings
3.1. Non-building structures (bridges, water facilities, power stations, etc.)	4.1. Routine maintenance
3.2. Military construction	4.2. Renovation and remodelling

amounts built of each type in these two groups, as well as their relative uniformity, make it easier and more reliable to establish and use 'typical' values of manhours per unit (e.g. The Building Centre of Israel, 1979).

As we continue to study Table 1, the availability of data and their reliability decrease substantially. Various projects of non-building structures, i.e. heavy construction or civil engineering works, have very little in common in terms of representative physical units for statistical processing; their most convenient common denominator is their money value, which may only indirectly hint about their labour requirements.

Demand for residential buildings

Major sources of demand

In most countries, residential buildings constitute the largest and the most uniform sector of building activities. New residential construction primarily serves – directly or indirectly – the following purposes:

(a) To provide dwellings for newly created households.
(b) To provide shelter for homeless people.
(c) To reduce dwelling density in existing housing facilities.
(d) To replace withdrawals from the existing stock of buildings.

The estimate of demand in this work was based on the following assumptions:

- The identified needs of one dwelling for each new household will be satisfied over the planning horizon (the years 1991–2000).
- The number of entirely homeless people (in Israel) is negligible. However, substandard conditions and irrepairable buildings will be taken account of, together with other withdrawals from the existing stock of buildings due to physical deterioration, urban development, population migration or natural disasters.
- The reduction of dwelling density will be gradually attained in the future, as it has been attained in the past, through a continuous increase in the average floor area of dwelling units (as explained later), through additions to existing residential buildings and, indirectly, through a declining number of

persons per household, All these factors will be taken account of in the estimate.
- There is a 'structural ratio' of vacancies created by ownership of a second dwelling, ownership of dwellings by non-residents, refurbishments, transfer of ownership, etc. It is assumed to remain around the present level of 5%. See Jones (1978), Struyk and Walker (1988) for other estimates.

Methods for projecting the number of new households

The most important component of residential-building demand – the number of newly created households – can be assessed by several methods, which differ from each other by their comprehensiveness, the number of factors taken into account and the relationships among these factors. Three of these methods are as follows:

1. Estimating the relationship between the number of households and several major demographic, sociological and economic parameters, which can be either determined or projected into the future. This type of aggregate approach (in terms of consumers) does not vary from the classical forecasting methods for any type of commodity as presented, for example, in Makridakis and Wheelwright (1978), United Nations (1967), and other sources.
2. Dividing the total population into pertinent states of potential heads of households, e.g. single, married, divorced, widowed, etc.; establishing for each state a consumption rate or 'Headship rate', i.e. the number of households per number of population. Given such a distribution at present and at future target dates, and assuming an unchanged or some projected headship rate, the number of dwellings necessary to satisfy future needs can be derived. The marital states can subsequently be subdivided into sex, age, or income subgroups and the differences in their headship rates noted. This approach requires information about the present and future division of the population into households or potential household heads, according to the pertinent status growth. It was adopted by Jones (1978), Pitkin and Masnick (1986), and others.
3. Dividing the population, as above, into the different marital states, and analysing the dynamics of their changes over the planning horizon, which for this purpose is divided into control periods of one or more years. The changes are affected by transitions from one state to another, e.g. single to married, married to divorced, etc., with a consequent creation or deletion of households. The analysis requires information on the present distribution of the population into marital-state groups, and on the probability of an individual's transition in a group from one state to another. That probability would obviously be affected by the age of the person – for example, the probability of divorce in the 29–34 age group is different from the 65+ age group. The method is described in The Government of Israel, Ministry of Construction and Housing (1985) and other sources.

The selection of the most appropriate method, from those listed above, depends on the availability and reliability of the relevant information, and the desired degree of accuracy of the study itself. In the present study, the first two methods were preferred, while the reasons for the third method not being employed were a lack of reliable data and a reluctance to engage in far-reaching assumptions.

Estimate of the aggregate demand for new dwellings

The aggregate demand for new dwellings, under the *first approach* as explained above, was derived from the combination of two major parameters, the population of Israel in the planning horizon and the average household size.

The first parameter – the population – was adopted from the forecast of the Israeli Central Bureau of Statistics. That forecast takes account of several possibilities of fertility and migration, and consequently offers three population forecasts – Low, Medium and High. Our estimate of demand for dwellings was based on the Medium projection of population, and its sensitivity was examined with respect to the Low and the High alternatives. None of these forecasts took into account the present rate of immigration, of course.

The second parameter is the average size of a household, which was projected into the future based on its very stable past trend. The results and projections are presented in Table 2. The figures in this table do not account for the needs of the new immigration wave in the 1990s. Its impact will be discussed separately.

Estimate of the demand for dwellings by various 'status groups'

In the slightly modified *second approach* of 'status groups', data were collected from The Central Bureau of Statistics (1989, 1985) and the attention was focused on the expected average annual changes within the following groups: marriages, divorces, deaths, non-family households, net withdrawals from stock, and

Table 2 Aggregate estimation of the demand for dwellings

Year	Expected population (thousands)	Average persons per household	Yearly increase in number of households	Period
1990	4608	3.61	22 200	1991 to 1995
1995	4974	3.58		
			24 000	1996 to
2000	5370	3.56		2000

migration balance. Some crucial remarks about each 'status group' are appropriate here:

Marriages

A marriage usually creates a new household, *unless* – one or both partners had already been heads of households before. In the latter case, a marriage can actually reduce the number of households. This will happen when the marriage takes place between divorced, widowed or single people, who had previously been heads of separate households. Since marriages constitute the largest single source of new households, a careful analysis of this factor is necessary to obtain accurate results.

In the absence of more detailed information, a rough estimate for new households could be derived from the number of first marriages, which was readily available from statistical sources.

Divorces

A divorce usually breaks one household into two separate ones (unless one of the partners moves in to live with parents or friends), and it thus usually creates a demand for one extra dwelling unit.

Deaths

Deaths are apt to eliminate existing households and to offer empty dwelling units for recycling, at a rough rate of one unit per two deaths. A closer look at the marital status, age and type of accommodation of each deceased person prior to his or her death can somewhat refine this rough rate of 50% but evidently will not drastically change it. In our specific case, the more thorough analysis led to a figure of 45% instead of 50%.

Non-family households

These are composed of unmarried couples, students, friends, room-mates, etc., who share apartments, mostly on a temporary basis. A need for additional dwellings results from an annual growth of this group of temporary households. Yet it is likely to be mitigated in the future together with other demographic trends.

Net withdrawals from stock

This item will be discussed later, since it is common to both this and the former method of estimation.

Migration balance

This refers to the net number of households added to, or subtracted from, the country in any particular year due to migration. This factor is pertinent only in countries with significant population changes due to immigration or emigration.

The information about marriages, divorces, deaths and migration is readily available in most countries on a periodical basis from statistical sources, and can be extrapolated into the planning horizon. The information about non-family households is obtained from census data and occasional sample surveys. Careful attention to these data should be given, if they are only collected at long intervals.

The limitation of this *second* method is its dependence on assumptions about the creation of dwelling needs by different causes, as explained before. For this reason it is usually less reliable than the first method. However, it also has several advantages: it highlights the magnitude and relative importance of each demand source, it can easily indicate the impact of possible effects of changes in demographic trends (e.g. immigration to Israel which was dealt with separately) on the estimate and it may also permit a periodical updating of the overall forecast due to such changes.

The breakdown of demand for *new* dwellings, obtained with this second method, is shown in Table 3.

The net withdrawals from the stock of residential buildings are caused by physical deterioration, substandard conditions, natural disasters, urban development (roads, parks), and change of use (e.g. dwellings to offices). The data about withdrawals are obtainable from statistical sources. In Israel, they constitute about 3% of the housing stock, annually.

Demand for non-residential buildings

Among the four major groups in Table 1, residential construction traditionally enjoys, in most countries, the best statistical attention and detailed treatment. Estimation of the future demand for this group of buildings is easiest, too, as it is based on the analysis of direct needs and past performance.

Detailed information about the construction of the second group (non-residential buildings), is also usually readily available. It is, however, more difficult to estimate the future demand for it than that for residential buildings.

The forecast of needs for non-residential buildings, in terms of their floor area, can be obtained through two approaches: from the extrapolation of past data for each type of buildings, or, for some types of buildings, from accepted norms as in the case of schools, hospitals, and others. A different approach, which was the one used in this study, draws on the fact that most of the services (education, health, etc.) and commercial activities (offices, stores, etc.) carried on in non-residential facilities, are generated by dwellers of residential buildings. Consequently, it can be expected that there would be a more or less steady relationship (over time) between the volumes of residential and of non-residential buildings, allowing of course for some prominent technological/occupational trends or changes in norms. In the particular case of Israel, the relationship between the floor areas of newly-built residential and non-residential buildings proved to be stable and fluctuated within a very narrow range around the ratio of 72% : 28% (28 m^2 of non-residential buildings for every 72 m^2 floor area of residential buildings). It is conceivable that a ratio of this kind, although dependent on local norms and standards, can be found also in other countries.

The remaining groups of non-residential buildings in Table 1 could not be so readily measured in physical units, and were separately estimated through different approaches, which will be described later.

Table 3 Demand sources for dwellings

Demand sources	Average for year (dwellings) 1991–1995	1996–2000
Marriages	23 950	23 800
Divorces	6700	7700
Deaths	(−14 050)	(−14 950)
Non-family households	2600	3000
Net withdrawals from stock	2700	3500
Total (with zero migration balance)	21 900	23 050

Summary of building construction needs

The total projected building construction – for both residential and non-residential purposes – is presented in Table 4, with the following clarifications:

1. The total floor area of residential buildings was obtained by multiplying the number of new dwelling units, as calculated in Table 2, by the expected average floor area per dwelling (including footprints of walls, balconies, staircases, etc.).
2. While the average floor area per dwelling of the approximately 1.2 million dwellings now existing in Israel is about 85 m^2, the average floor area of new dwellings is substantially larger (around 130 m^2), thus it increases the average dwelling size by approximately one square metre annually. This improvement is obtained, as noted before, by a continuous 'upward' movement of the population from smaller to larger dwelling units.
3. The total floor area of non-residential buildings was estimated according to the aforementioned ratio of 28:72.
4. Based on statistical sources, the annual addition of floor space to existing buildings was estimated as being equal to 6% of the new residential buildings.

Translating physical quantities of new buildings into labour requirements

Three major technologies are employed in building construction in Israel. The first, referred to here as *conventional,* uses *in situ* cast-reinforced concrete slabs and columns, and masonry of concrete blocks for exterior walls and partitions. The second method – *prefabricated* – uses precast concrete components for floor slabs and exterior and interior walls, while the third – *industrialized on site* – uses concrete slabs and walls cast on site in room-size moulds, and prefabricated exterior facades.

As explained earlier, it was necessary to establish a whole database of manhour inputs for each skill per square metre of each type of construction. For residential housing this had been done in great detail in Warszawski and Segal (1976) and was especially updated for this study. For non-residential buildings, however, some simplified assumptions had to be made, due to the scarcity of data, which was also justified by the insignificant sensitivity of the total results to these assumptions. Table 5 presents typical manhour inputs, on site, of major construction skills, per square metre of residential dwellings.

Table 4 Projected new building construction for all purposes

Yearly averages for the period (units)	1991–1995	1996–2000
Increase in number of households (dwellings)	22 200	24 000
Replacing withdrawals from stock (dwellings)	2750	3500
Demand for residential dwellings (dwellings)	24 950	27 500
Average size of new dwellings (m^2)	136	143
Total floor area of new dwellings (10^3 m^2)	3390	3930
Total non-residential floor area (10^3 m^2)	1320	1530
Total floor area of new buildings (10^3 m^2)	4710	5460
Additions to existing buildings (10^3 m^2)	280	330
Total construction of buildings (10^3 m^2)	4990	5790

Table 5 Typical labour inputs in residential construction in three major methods (manhours per sq. metre)

Major skills	Conventional/ traditional	Prefabricated/ precast	Industrialized on site
Foremen	2.39	1.38	1.64
Formwork carpentry	3.60	0.90	0.90
Steel reinforcement	1.00	0.40	0.40
Concrete casting	1.80	0.45	0.45
Skeleton erection	–	0.85	1.83
Masonry	1.50	–	0.05
Plastering	3.20	1.05	1.27
Tile-setting	1.40	1.10	1.10
Painting	1.20	0.99	1.39
Plumbing	1.55	0.73	0.63
Electricity	0.85	0.52	0.62
Other trades and unskilled labour	5.41	5.43	6.04
Total	23.90	13.80	16.40

Although prefabricated and industrialized construction require, respectively, about two and one additional off-site manhours per square metre they are still quite attractive from their labour input aspect. Moreover, they mostly save manhours in those labour-intensive skills of which there is a very severe shortage in many developed countries.

Databases in the format of Table 5 can be established for each country regarding major construction methods of various types of buildings. In order to fit into the general model presented in Figs. 1 and 2, they must finally result in weighted averages of labour inputs of different skills per physical unit of each type (or aggregated types) of construction.

Obviously, there are trade-offs between the amount of effort required to establish such databases and their accuracy. It appears that some compromises, aggregation of categories and approximations are unavoidable. Large categories, of course, should get more detailed attention than small categories.

Other construction works

Non-building construction projects mainly include roads, highways, other transportation works, waterways, water-supply works, harbours, airports, power stations and utilities. Unlike in buildings, it is almost impossible to evaluate these works (especially those projects which employ building construction labour) in other than monetary terms. In other similar studies (Warszawski and Segal, 1976), an attempt was made to derive resource requirements from money allocations through an analysis of representative projects in each group. In this study, however, it was revealed that in past labour surveys the number of building construction workers employed in non-building projects was relatively constant and small (about 5%) relative to workers employed in building construction. It was therefore assumed that both the number and the composition of these workers will not change substantially – within an acceptable margin of error – during the planning horizon.

Military projects were another type of construction studied in this context. Most of these included conventional buildings – barracks, warehouses, offices and various civil engineering works. Although they are not included in regular statistical reports, data about them were procured, analysed and included in the study.

Maintenance work

With the ageing of the building stock, an increasing share of the resources devoted to building, in Israel as in other countries, is spent on maintenance and renovation.

A large share of such maintenance work is done by small unorganized contractors, whose activities are not clearly reflected in the regular statistic data. Consequently, labour-input requirements for maintenance work must be assessed indirectly.

Three major sources of information were available for this assessment, the parallels of which may be found in other countries as well:

1. Data on typical maintenance expenses of two major public housing agencies which administer much of the rental housing stock in Israel.
2. Extensive Life Cycle Cost studies Alweyl (1987), which defined 'normative' maintenance expenses for different types of buildings and building components.
3. Breakdown of maintenance expenses taken from Family Expenditure Surveys conducted periodically by the Central Bureau of Statistics.

Combination of data from these three sources led to an estimate of the total expense on the maintenance of buildings and the breakdown of this expense into major categories, as shown in Table 6. Finally it led to the assessment of the number of workers required in each skill, as shown in Table 7. Some assumptions about maintenance work done by tenants themselves, and by construction workers in their overtime (based on observed patterns) were also included in the estimate.

Table 6 Distribution of maintenance cost of residential buildings

Type of work	% of cost
Painting	38
Plumbing	15
Electricity	7
Plastering	10
Tile-setting	7
Carpentry and aluminium	6
Roofing and insulation	9
Other works	8
Total	100

Table 7 summarizes the combined expected demand for construction labour in the major skills, during the first and the second halves of the coming decade. Construction of new buildings will still be the major activity in that period, but the relative share of maintenance work will gradually increase.

Labour supply in the construction sector

Periodical labour surveys are routinely performed in most countries. The types of these surveys differ with respect to their frequency (and therefore relevance of their information) and the size of the sample upon which they rely (and therefore their statistical reliability). Two types of such surveys are conducted in Israel: one conducted quarterly, the other conducted every 10 years. The former includes 1% of the total labour force and gives an up-to-date approximation of the total labour force, but its breakdown into categories is not reliable due to the small sample size. The 10-year survey is conducted within the framework of the total population census. Although the most recent census was in 1983, the authors decided to use its findings for the breakdown into work categories, as a guideline for the present composition of the construction labour force The Central Bureau of Statistics (1987).

The data for both types of survey are collected, analysed and published in accordance with the International Labour Organization (ILO) classification into occupations (ILO, 1969), and the United Nations (UN) classification into economic branches (UN, 1967). Tables 8 and 9 are authentic reproductions of both relevant classifications, taken from The Central Bureau of Statistics (1987).

These classifications suffer from several limitations:

(a) Only eight specific categories of building occupations are explicitly enumerated. Such important trades as formwork carpenters, building painters, building electricians and others are not included in group '85' of 'builders' but 'hidden' among other occupations (carpenters, electricians, painters), while their natural place would be among the building trades.

(b) There is no clear distinction between occupation and economic branch. While 'occupation' only refers to the type of work the person performs regardless for whom, 'economic branch' refers to the kind of organization that he or she works for, no matter in which occupation. For example, an economic sub-division entitled 'tile-laying' may naturally imply tile-laying occupation, while in fact it includes also the clerks, accountants,

Table 7 Summary of demand for construction workers in Israel

Workers' skill	For the period 1991–1995				For the period 1996–2000			
	New buildings	Maintenance	Other purposes	Total	New buildings	Maintenance	Other purposes	Total
Formwork carpenters	11 100	–	1500	12 600	13 100	–	1500	14 600
Steel reinforcement	3100	–	400	3500	3700	–	400	4100
Masons	4400	–	500	4900	5200	–	500	5700
Tile-setters	4600	1500	300	6400	5400	1700	300	7400
Plasterers	10 000	2100	600	12 700	11 600	2400	600	14 600
Plumbers	3800	3100	300	7200	4300	3700	300	8300
Electricians	2800	1500	200	4500	3300	1700	200	5200
Carpentry fitters	1900	1300	200	3400	2200	1500	200	3900
Painters	4100	7900	600	12 600	4800	9300	600	14 700
Foremen	7500	2300	1100	10 900	8800	2700	1100	12 600
Other workers	22 000	3600	5300	30 900	25 000	4100	5300	34 500
Total	75 300	23 200	11 000	109 600	87 400	27 100	11 000	125 600

Table 8 Standard classification of construction related occupations

85	Builders
850	Foremen
851	Builders
852	Tile-setters
853	Plasterers
854	Insulators
855	Glaziers
856	Iron workers
857	Concrete pourers
858	Prefabricated structures
859	Builders NEC
85+	Builders NS
86	Construction machine operators
860	Foremen
861	Wiremen and cablemen
862	Crane operators
863	Excavating machine operators
868	Building machine operators NEC
86+	Constr. machine operators NS

drivers, production workers and other functionaries employed in the business of tile laying.

(c) There is no indication of the skill level of the workers. For example, unskilled labour employed temporarily as helpers (in masonry) can, and probably will, define themselves as masons, which may lead to incorrect conclusions with respect to the existing potential in this occupation.

Despite these and other limitations, a fairly accurate estimate of the supply of workers was finally derived from an in-depth analysis of the raw data of the census. The details of this analysis are, however, beyond the scope of this paper.

Table 9 Standard classification of economic branches

4	Construction
40	General contractors
400	General contractors
40+	Building NS
41	Special contractors
410	Special contractors
411	Building skeleton
412	Coating
413	Tile-laying
414	Plumbing
415	Electrical work in building
416	Building carpentry
417	Painting
418	Special contractors NEC
41+	Special contractors NS
42	Public works and civil engineering
420	Public works mixed
421	Site works
422	Road construction
423	Heavy engineering
424	Water, sanitation construction
42+	Public works NS

The results of the expected demand, and the existing supply, with respect to the main building occupations, are presented in Table 10. The estimate of the existing supply of labour is mostly based on the results of the 1983 census, which was found to be more reliable than subsequent surveys. The relatively young age of workers, as reported in the survey, assumed a considerable stability of occupational potential in the forecast time range, which could be activated, if needed, by appropriate incentives.

The supply figures did not include 'guest labour', or foreign workers, who constituted about 40% of con-

Table 10 Supply versus demand of major construction skills

Workers' skill	Present supply	Demand 1991–1995	Demand 1996–2000
Formwork carpenters	5200	12 600	14 600
Steel reinforcement	1100	3500	4100
Masons	3800	4900	5700
Tile-setters	3600	6400	7400
Plasterers	3200	12 700	14 600
Plumbers	6400	7200	8300
Electricians	5100	4500	5200
Carpentry fitters	2800	3400	3900
Painters	5200	12 600	14 700
Foremen	10 100	10 900	12 600
Other workers	17 100	30 900	34 500
Total	68 600	109 600	125 600

struction labour in Israel and bridged the existing gap between demand and supply. The information created by this study was to form the basis for decisions about dealing with this gap in the future.

As noted before, the findings of the study implied that the supply of local construction workers will remain relatively stable in the next decade. The recommendations indicated that the expected shortage of local labour for new construction can be largely satisfied by increasing the share of labour-saving industrialized methods. As far as maintenance works are concerned, the growing need of workers in this category is to be met by initiating training programmes specifically oriented towards this type of work.

Conclusions

The paper dealt with forecasting of needs for building resources as a basis for long-range planning. It presented a forecasting methodology and illustrated it by the special case of the Israeli building market.

Here are some conclusions of a general nature which may be of assistance in similar studies in other countries.

1. The demand for construction resources involves both building and non-building construction. The first is measurable in physical units of floor area and can be readily converted into resources needed for its execution. The other is less amenable to physical measurement, and the resources necessary for its realization must be indirectly inferred from its monetary value.
2. A major component of building construction is residential buildings. The demand for new residential buildings depends on the growth in the number of households, the average floor area of new dwellings, and the replacements needed for withdrawals from the existing building stock. This information can usually be derived from the available statistical data.
3. Demand for many non-residential buildings, such as schools, hospitals, shopping centres, public administration, etc., is directly related to the demand for residential buildings. Future demand can therefore be inferred from the forecast demand for residential buildings.
4. A growing share of the total building labour is needed for maintenance and renovation work of the existing building stock. Information about maintenance expenses is available from the records of rental agencies and owners of commercial buildings, from life-cycle costing data, and from statistical surveys of maintenance expenses. These data must be then converted into labour needs.
5. The demand for construction labour in various non-building civil engineering works can be derived from the analysis of representative projects in the more prominent categories or inferred from available data about labour employed at present in similar types of work.
6. A well-structured and reliable survey of existing construction labour is a prerequisite for a realistic estimate of future labour supply. The present ILO classification of building occupations cannot efficiently serve as a basis for a reliable survey of that type. A more exhaustive and distinctive classification must be employed for this purpose.
7. An expected shortage of construction labour can be mitigated by the employment of labour-saving industrialized methods, and by the introduction of training programmes and incentive schemes.
8. A long-range forecast should not be entirely dependent on existing trends, but take into account any available information which may conceivably affect the demand or supply

factors – even if this information is not certain and ill-structured. The impact of significant anticipated changes cannot be dealt with only by sensitivity analysis. The forecast should be frequently updated, and the ensuing grading should be flexible enough to accommodate the changes in demand and supply.

Impact of the immigration surge

The original forecast described in this study was completed in 1989, based on the outlook in the years 1975–88 – when the demand for buildings was generated by internal demographic factors, rising standards, and insignificant migration balance. A radical change occurred in 1990 and 1991, when a new political reality (in the former Soviet Union) prompted a tremendous immigration wave which could conceivably increase the population of Israel by 20–40% over the years 1991–95. The immediate enormous impact of this change on the demand for buildings is quite obvious. The government has had to cope with the sudden increase in the demand by encouraging import of rapid (mostly lightweight) construction methods, providing incentives to local contractors to increase their construction output, permitting import of foreign (guest) workers, and increasing its involvement in the mortgage and rental markets. The long-range effects of the present immigration wave on demand and supply of resources is much more difficult to assess for the following reasons:

On the demand side

(a) The level and stability of the immigration influx over time. The estimates at present vary over a very wide range.
(b) The demographic composition of the immigrants, and its effect on new households creation.
(c) The government policy with respect to housing assistance – an essential factor in view of the very meagre economic means of the immigrants, and

On the supply side

(a) The long-range economic viability of various rapid (mainly lightweight) construction systems, which were imported in order to satisfy the immediate demand for buildings.
(b) The long-range government policy with respect to importing of guest construction workers – permitted for the first time during the present construction boom.
(c) The prospects of luring into the construction trades new immigrants who were formerly employed in other professions – some promising trends in this respect have been discovered.

The methodological treatment of each one of these factors, under the existing uncertainty, is by itself a very challenging subject. The professional interest in its detailed discussion seems to be limited, however, to countries in which such exceptional conditions do, or might occur, and those are very few. Moreover, it is expected that the high uncertainty with regard to the immigration volume, and the application of short-range solutions, which exists now, will not continue for more than 3 to 5 years. Afterwards, the situation will stabilize, and resources planning can be performed with the methods presented here, albeit with a somewhat different database.

For all those reasons, it was decided to omit from this paper any quantitative treatment of the present immigration effects and to illustrate the methodological approach presented here by data pertinent to the previous demographical situation.

An important lesson can be drawn, however, from this particular case. First, a long-range forecast cannot be entirely dependent on existing trends. The planners must take into account any available information about possible demographic, economic or political changes which may affect the forecast, even if such information is unstructured and uncertain. Second, if changes are anticipated, and they may be very significant, their impact on decisions cannot be assessed merely by sensitivity analysis which implicitly assumes moderate deviations from a central trend. The correct approach would be rather to frequently update the forecasts in view of newly obtained information, and make the forecast-dependent plans flexible enough so that they could be modified as needed.

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