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P.O. Box 527
Ottawa, Ontario
K1P 5V6

C.P. 527
Ottawa (Ontario)
K1P 5V6

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DISCUSSION PAPER NO. 340

Employment, Income and Occupational Effects of Computer-Based Automation in Canada

by

Thomas H. McCurdy

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RÉSUMÉ

Le présent document décrit un modèle économique mis au point pour simuler l'incidence éventuelle des techniques informatiques d'automatisation sur les modes d'organisation de l'emploi et des professions dans l'industrie canadienne. Le modèle combine les caractéristiques d'un système macroéconomique keynésien avec la structure industrielle détaillée de l'analyse intersectorielle et la répartition de l'emploi entre les professions, d'après des données de recensement. Le fonctionnement du modèle met en évidence un certain nombre de techniques innovatrices pouvant intéresser les économistes.

Le modèle (appelé MESIM) se fonde, du point de vue statistique, sur une analyse de données chronologiques couvrant la période de 1956 à 1983, et fait aussi appel à des études quantitatives particulières sur les nouvelles technologies informatiques qui devraient avoir des répercussions sur l'économie des entreprises canadiennes jusqu'en 1995. Pour décrire les résultats des projections découlant des simulations, l'auteur recourt à une série de scénarios qui tiennent compte de divers facteurs comme : 1) le rythme de diffusion des technologies, 2) le rôle du commerce international et 3) le degré de succès de l'adaptation de la main-d'oeuvre aux nouvelles possibilités d'emploi.

Un des principaux rôles du modèle MESIM consiste à illustrer, d'une part, la nature des mises à pied qu'entraîneront, dans les industries et les professions, les augmentations de productivité provoquées par les nouvelles techniques informatiques. D'autre part, le modèle peut aussi refléter les réemplois attribuables au fait que ces mêmes technologies contribueront à accroître le revenu réel et les dépenses. Mais sur le plan des politiques en cause, la constatation la plus importante est que les deux séries d'effets ne coïncident pas. Il s'ensuit donc que la main-d'oeuvre devra s'adapter pour corriger le "manque de concordance" entre les mises à pied dont nous avons parlé et les nouvelles possibilités d'emploi créées par le progrès technologique.

ABSTRACT

This paper describes an economic model that is designed to simulate the impact of computer-based automation on future Canadian industry employment and occupational structure. The model combines the features of a Keynesian macroeconomic system with the detailed industrial structure of input-output analysis and census-based occupational distribution of employment. The mechanics of the model feature a number of innovative techniques that are of professional interest to economists.

The model (called MESIM) is statistically based on an analysis of historical data covering the time period 1956-83, together with special quantitative studies of the new computer-based technologies that are expected to impact the Canadian business economy up to the year 1995. The results of the simulation projections are described by a series of alternative scenarios, depending on such factors as: (1) the rapidity of technological diffusion, (2) the role of international trade, and (3) the success of labour adjustment to new employment opportunities.

One key aspect of MESIM is to illustrate, on the one hand, the nature of industrial and occupational labour displacement that would follow from the productivity-raising impacts of the new computer-based technologies. On the other hand

the model is also capable of illustrating the industrial and occupational labour re-employment that follows from the real income- and expenditure-raising impacts of the same new technologies. From a policy standpoint the crucial finding is that the two sets of impacts do not coincide. Thus there is a labour adjustment problem to bridge the "mismatch" between the old employment displacement and the new employment opportunities created by technological change.

CONTENTS

FOREWORD

This paper provides the technical background material for the major part of Chapter 4 "Looking Ahead" of the Economic Council's Research Report Innovation and Jobs in Canada. The latter Report contains a summary of the most important projections (to the year 1995) yielded by an economic simulation model called MESIM (MicroElectronicSIMulation). The results are described in non-technical language and in such a way as to integrate with other chapters of the Report. Hence there is very little explanation regarding methodology and almost all technical details are excluded. The present paper embodies the technical explanations that would be of interest to professional economists. The paper also contains many more projection results that are not described in the ECC Report.

Interested readers are also directed to an earlier version of MESIM, including projection results to the year 1990, that was published by the author in Journal of Policy Modeling (1987, pp. 269-297). Although that version of the model is superceded by the one described in the present paper, the earlier publication contains a useful account of the basic model's underlying structure.

The author, Professor Thomas H. McCurdy, is a professor with the Department of Economics at Queen's University.

Judith Maxwell
Chairman

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I. INTRODUCTION

There is considerable disagreement about the employment effects of computer-based technical change. There have been many dire predictions concerning the potential net loss of jobs due to automation made possible by microelectronics. However, others argue that technological progress promotes increased productivity, real income and growth. Accordingly, if workers are displaced by machines, such technological unemployment should only be temporary since appropriately operating market mechanisms (resulting in changes in relative product and/or factor prices and in expenditure of increased incomes) would ensure that those workers are re-employed somewhere in the economy. Therefore, according to this view, the displacement of workers will be far worse if the new technology is not adopted. In an open economy, the increased competition from newly industrializing countries and from other advanced industrialized countries makes technical progress necessary in order to retain export markets and also to prevent import penetration (the loss of domestic markets to foreign producers). Changes in international comparative advantage and thus in the world distribution of income may be associated with the effective adoption of the new technology.

Is it possible to resolve the disagreement concerning the potential impact of technical change on employment? Without wishing to minimize the problems of adjustment (particularly for the individuals affected), earlier fears of sustained widespread technological unemployment in response to, for example, assembly line production and mainframe computers did not materialize. It is difficult to find historical examples of sustained technological unemployment. In fact it would appear that countries with a fast rate of technical innovation have had low rates of unemployment rather than the other way around. Are there reasons to believe that the latest new technology (the microelectronics "revolution") has special characteristics which might make its potential (un)employment implications different from earlier technical revolutions?

It is virtually impossible to predict the aggregate and structural implications of the pervasive technological and organizational changes which are likely to result from, and accompany, microelectronic-based technical change. Nevertheless, it is possible to analyse specific aspects of the impact of this technical change. In particular, successful technical change invariably involves fewer inputs per unit output of goods and services. Many components of this new technology--such as, computer-based automation-- appear to be labour saving in that the labour required per unit of output falls. This heightens fears that jobs will be lost. For example, automation is clearly a threat from the viewpoint of a bank teller whose job is being replaced by a machine and who thus must retrain for different tasks within the firm or perhaps even search for a new job in another firm or industry.

However, the idea that there is a fixed number of jobs for which humans and machines compete is clearly fallacious. From the viewpoint of society as a whole, we need to recognize that new jobs are created (often indirectly) by the new technology, and that there are feedback effects of higher real incomes (the productivity dividend). That is, technical change usually improves productivity (output per person) and thus potentially improves our standard of living -- either in the form of higher income or an increase in leisure in the form of shorter working hours.

Therefore, case studies of particular industries or occupations can be misleading with respect to the overall (net) effects, since job displacement is an important part of growth. Structural dynamics initiated by technical change, and accommodated by changing patterns of final demand, should induce movement of workers from declining sectors to new opportunities in growing sectors.

Nevertheless, even in the context of potential technological unemployment due to slow adjustment towards a new technological and occupational structure, there are important empirical issues. One of these issues is the potential structural unemployment which is manifested in a mismatch (for occupations (skills), sectors and even countries) of displaced positions and the vacancies created in the growing sectors. Modeling the potential sources of future occupational and sectoral shifts provides an indication of the magnitude and speed of adjustment that will be required to avoid such structural unemployment.

This paper reports results from a simulation study of some potential implications, for the Canadian economy, of the computer-based automation (CBA) technologies analysed by Leontief and Duchin (1986). CBA technologies applied to production processes (robotics, computer numerically controlled (CNC) machine tools, computer-aided design and manufacturing (CAD/CAM)) and offices (information processing equipment) are only one component of the microelectronics revolution. Therefore, this application of the model to computer-based automation has a more specific focus than an earlier application (McCurdy, 1987), and also benefits from an extensive collection of more recent Canadian data on machine tools, robots and computers. Furthermore, the CBA applications of microelectronic-based technology have more precisely quantifiable impacts on labour productivity and hence on changes in the demand for workers by industry and occupation.

Since computer-based automation reduces the demand for labour per unit of output, if output stays constant after the CBA is introduced, then workers will be displaced for some occupations and industries. However, when/if the appropriate structural adjustments take place, those displaced workers will be re-employed and national income will increase. An increase in the rate of diffusion of the new technology will imply more initial displacement but the higher productivity gains should ultimately improve national welfare. These comparisons highlight the importance of the required structural adjustments. Our simulation model computes the potential size of these effects at both disaggregated (by sector and occupation) and aggregated levels of detail.

The results indicate that the current stages of automation should not seriously threaten the total number of jobs available. Historically, the economy has absorbed the workers who have been displaced by increased productivity and automation. The calculations of the effects of computer-based automation suggest that the magnitude of absorption or new job creation required (to prevent technological unemployment) will be relatively small when compared with that necessitated by the increased participation rates of women and the demographic bulge associated with the post-war baby boom. Nevertheless, the results also show that the impact of the new technology will be more severe for some occupations and sectors than others. Matching of skills available and those required by the new technology may not be trivial. In addition, the implications for displacement of females versus males are clearly different for office than for production applications.

II. MODELING METHODOLOGY

II.1 Introduction

It is difficult to predict the **net** (that is, after any structural and economic adjustments which facilitate matching of displaced workers with job vacancies brought about by the new technology) employment implications of CBA by aggregating industry studies or survey responses. Such studies[2] are very important as sources of information concerning the sectoral detail. Nevertheless, in order to compute the effects for structural unemployment (sectoral and occupational mismatches) and for aggregate (un)employment, it is also necessary to explicitly model: the sectoral interdependencies; the interactions between supply and demand[3] -- such as the feedback initiated by the productivity dividend; and the potential for export-led growth

2 See, for example, DeMelto, McMullen and Willis (1980), Globerman (1984), Ontario Task Force on Employment and New Technology (1985), Pilorusso (1982), Policy Studies Institute (1985), and Werneke (1983).

3 See, for example, Neary (1981) and Whitley and Wilson (1982).

and/or for import penetration by those countries which adopt a more rapid diffusion of the new technology.

Earlier literature on formal modeling of the impact of microelectronics on employment has been surveyed by OECD (1982). Most of these models - notably, Bundesministerium fur Wissenschaft und Forschung (1981) and Whitley and Wilson (1982) -- are either input-output models or large scale macroeconometric models with an appended input-output structure. More recent modeling of the employment impact of new technology has been reported in Dungan and Younger (1985), Howell (1985), Leontief and Duchin (1986), Roessner (1985) and Rumberger and Levin (1985).

This paper uses a simulation model (MESIM for MicroElectronic SIMulation) to provide some empirical results related to potential technological unemployment for Canada. The objective is to compute the range of feasible post-technical-change adjustment or transition paths for any particular scenario, and also to compare the effects of alternative scenarios where the latter are identified by, for example, different rates of diffusion for the new technology.

II.2 MESIM Solution Structure

MESIM integrates a thirty-nine sector input/output structure and the national income and product accounts into a single framework. That is, an econometric model is fitted to real (1971 constant dollars) aggregate time series data to model the level of final demands, while the evolving input/output structure disaggregates those levels across detailed sectoral, occupational and commodity classifications.

The primary innovations in the static structure[4] of MESIM are the occupational disaggregation [as in Leontief and Duchin (1986)] and our method of computing the range of feasible post-technical-change transition paths for each scenario. As discussed below, there are also novel features of the dynamic structure of MESIM.[5] For example, our method of computing the reference path, which calibrates the model to annual historical data and to out-of-sample extrapolations of the historical trends, incorporates substitution trends both from the supply side (such as, the increasing use of plastics) and those initiated by demand (for example,

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4 See de Boer and Donkers (1985) for a discussion of the relationship between the input/output specification of the static production technology and alternative specifications.

5 For additional details concerning the model structure see McCurdy (1987).

increasing demand for services relative to durables). These extensions alleviate some common criticisms of Keynes-Leontief-type models.

In our model, three solutions are computed for each year. For example, for year 1995 (or for any other year 19xx): 1995(ref) is the **reference** (or baseline) solution--that is, without the computer-based automation (CBA); 1995(shock) is the post-CBA or **shock** solution which incorporates the effects of the CBA technical change while keeping the level (but not the structure) of final demand equal to that along the reference path; and 1995(final) is the solution in which displaced workers, computed using the 1995(shock) solution, are re-employed using the new technological/occupational structure. This final solution allows us to compute the income and associated final demands made possible by the new technology using reference solution overall employment levels.

While the model does not predict the exact level of unemployment in any given year, it does provide upper and lower bounds on the unemployment likely to arise due to computer-based automation. The latter is provided by the post-technical-change (final) solution whereas the former is approximated by the post-technical-change (shock) solution.[6] Which of these solutions will be closer to the actual unemployment will depend on the ability of the labour market to provide new jobs for displaced workers. If adjustments are instantaneous such that all workers displaced by the new technology are re-employed immediately according to the new technological/occupational structure, then 1995(final) will be the relevant post-technical-change solution. At the other extreme, if output remains at reference (no CBA) levels throughout the simulation, then the predicted post-technical-change solution is 1995(shock) so that very few of the displaced workers will be re-employed. Of course, additional structure on the model provided by, for example, a theory of skill acquisition, could predict a particular solution between 1995(shock) and 1995(final).

Time paths are generated for each of the above three solutions by computing those solutions year-by-year from 1982-95 using the converged values for each path in year t-1 as starting values for the corresponding path in year t. The demand side evolves according to the projections of the econometric model suitably perturbed by feedback from the CBA in the case of the two post-technical-change solutions 19xx(shock) and 19xx(final). This feedback includes

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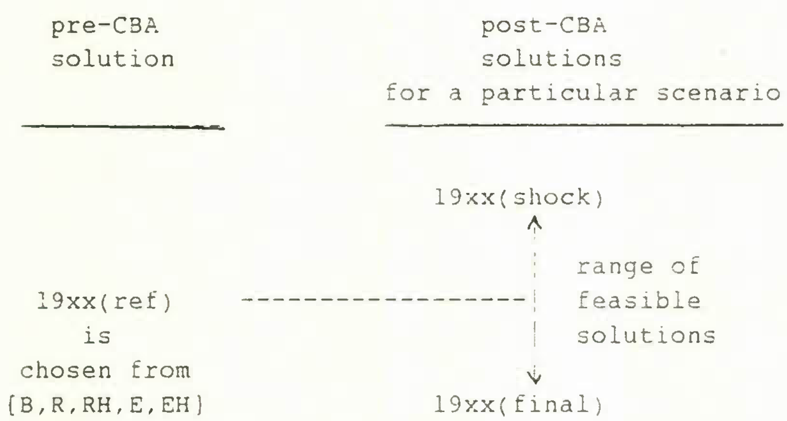
6 Total displacement is computed using outputs from the reference solution. The difference between total employment for the pre-technical-change (reference) solution and that for the post-technical-change (shock) solution is approximately equal to total displacement since, although the level of final demand is the same for these two solutions, the change in its structure brought about by the technical change (for example, different sectoral allocations of investment and imports -- see Appendix B.2) will have some employment implications.

the income effects to factors from the "productivity dividend" , the change in the structure of final demand, and the change in the structure and level of demand for various occupations (including employees versus self-employed). The supply side evolves according to the reference path chosen and the particular assumptions concerning the impact and the rate of diffusion of the new technology.

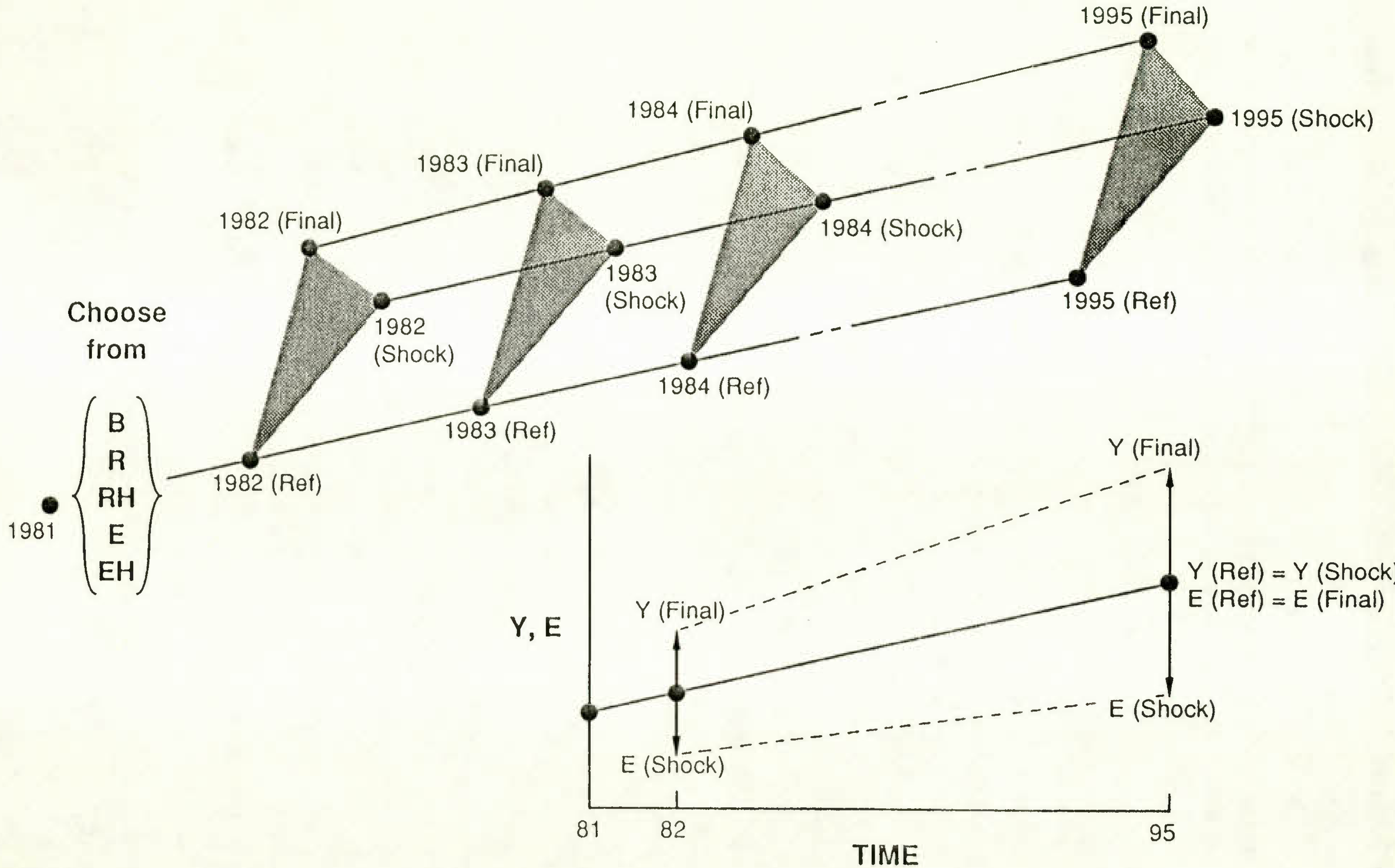
One can choose alternative reference (or baseline) paths for out-of-sample simulations. Table 1 compares five alternative reference paths which are labelled B, R, RH, E and EH. The differences between these alternative baseline paths are defined in the key to table 1 and are also discussed in detail in section IV below. A particular choice of reference path will affect the **levels** of the variables -- particularly the unemployment rate -- but will not substantially alter the predictions of the changes brought about by CBA.

FIGURE 1



In summary, as illustrated in figures 1 and 2, two post-technical-change paths (19xx(shock) and 19xx(final)) are computed for each scenario relative to the chosen reference or baseline path (19xx(ref)) which the alternative scenarios have in common. Solution path 19xx(final), which computes the implication of re-employing workers displaced by the CBA is very important because it incorporates the potential feedback, unlike Bundesministerium (1981) and other Keynes-Leontief-type models criticized by Whitley and Wilson (1982) and OECD (1982). While it might be useful to model the **behavioural** reactions to the CBA explicitly (that is, trace a particular transition path from 19xx(shock) to 19xx(final)), this is very difficult to do empirically without additional information -- for example, elasticities of demand for skills or occupations. Our two post-technical-change paths bound the range of feasible transition paths.

Figure 2
Calibration of post-technical-change solutions to the baseline path
and comparison of the three solution paths in output and employment space


1995 (Final)
1995 (Shock)
1995 (Ref)
1984 (Final)
1984 (Shock)
1984 (Ref)
1983 (Final)
1983 (Shock)
1983 (Ref)
1982 (Final)
1982 (Shock)
1982 (Ref)
Choose from
B
R
RH
E
EH
1981
Y, E
Y (Final)
E (Shock)
Y (Final)
Y (Ref) = Y (Shock)
E (Ref) = E (Final)
E (Shock)
81
82
95
TIME

With respect to the econometric structure, in addition to the usual aggregate expenditure functions for consumption, exports and imports, and tax and transfer functions, a link between demand and supply is incorporated via an econometric estimation of the time series relationship between factor incomes (wages per employee and profits per self-employed hour) and productivity (per hour). This important link provides a channel through which the productivity dividend or income effect of the technological progress is transmitted to final demand. Given the appropriate definitions and accounting identities, a very simple model of aggregate expenditure and income is constructed.

Although the demand functions have conventional interpretations, they are not motivated primarily by behavioural theory. Rather the demand model is designed essentially to serve two important functions. Firstly, the econometric demand relationships provide one side of the reference path solution which will serve as the baseline for comparative scenarios. Recall that the reference path calibrates the model to annual historical data and to out-of-sample extrapolations of the historical trends. Therefore, the demand structure was designed to track the data well. The second important role of the demand specification is to focus on the final demand feedback or compensation effects in response to the supply side technological change. Thus our specification explicitly incorporates the transmission of the real income effect or productivity dividend.

MESIM does not explicitly use relative prices to predict a particular transition path.[7] However, all the substitution trends embodied in the annual, constant dollar, input/output use (input), output and final demand matrices at the medium (thirty-nine sector) level of aggregation are utilized. Furthermore, due to the dominant nature of the new techniques introduced by CBA, the income effects and the dynamic substitution effects (such as the changes in the structure of investment as the new technology is embodied) will be quantitatively more important than intraperiod substitutions induced by relative price changes. In other words, we are not distinguishing between shifts in the production function and movements along it as we track changes in the production points. Nevertheless, the dynamic evolution of cost prices and the associated shifts in the factor price frontier could be computed as output from MESIM.

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7 If detailed occupational demand elasticity estimates of the type presented in Denny and Fuss (1983) for a Canadian telecommunications firm were available for all industries, the applied general equilibrium method would be a particularly attractive alternative methodology. Also, see Siedule and Leckie (1983).

III. IMPACT EFFECTS OF COMPUTER-BASED AUTOMATION

Considerable attention was given to matching the technical change data with the economic structure of our model. One source of widely diverging predictions for the impact of CBA on (un)employment is the failure to incorporate the fact that only a fraction of the tasks of a particular worker will be affected by the technical change and also the fact that often the impact is more similar across occupations than it is across sectors. That is, there are both important sectors (such as the electronic and the machinery and equipment producing sectors) and important occupations (such as information processing operatives, machinists, assemblers, etc.) which need to be distinguished in modeling the technical change. A further source of the divergent predictions concerning the effect of CBA is the variety of different opinions concerning the rate of diffusion.

We have addressed these issues by using shock data which incorporates: the fraction (S) of workers' hours potentially affected by computer-based automation; the labour productivity using the new technology relative to that using the old technology (P); and alternative rates of diffusion (DF) which tell the model how quickly we wish to approach the potential levels of automation in the various sectors. The post-technical-change input matrix will incorporate the fact that the same output can be produced with fewer labour inputs. Also, the inter-industry input matrix is adjusted to reflect some changes in material inputs due to the CBA technical progress.

Appendices B and C report details on sources and methods of implementation of these data which predict the impact of CBA on labour productivity and the material input requirements. This study is indebted to the Leontief and Duchin (1986) study which was a major source for these data. The impact of a microprocessor-based machine doing a particular task in a particular industry should be similar in Canada and the United States. Of course, the rate of adoption of such machines and the trade implications could be very different across countries. This is one reason that we compute alternative scenarios with respect to those variables.

IV. RESULTS

Data (sectoral/occupational employment matrices, final demand, sectoral outputs and inputs) from the post-technical-change paths -- 19xx(shock) and 19xx(final) -- are compared to those from 19xx(ref) and decomposed according to changes originating from the supply side (productivity and input changes) versus final demand changes. A comparison of the 19xx(final) path with the 19xx(ref) path isolates the structural adjustments (occupational and sectoral) required to re-employ the workers displaced by the CBA – the latter having been computed using the difference between the 19xx(shock) and the 19xx(ref) solution paths. Displaced workers by occupation, sector and application (production and office) are reported for total displacement (both levels and percentages of base-year commercial employment) and female displacement.

IV.1 Displacement of Workers Relative to Alternative Reference Paths

Table 1 compares the displacement effects of CBA and the (un)employment implications of choosing alternative out-of-sample reference (or baseline) paths. With respect to choice of a reference path, one view is that the microelectronic-based technical change is revolutionary, while according to others it is evolutionary in the sense that is a continuation of past trends of technical change. We model the former view by using a revolutionary reference path (R) which allows the historical trends for productivity improvement to continue out-of-sample by incorporating the extrapolated rates of change for labour productivity (1/Q) and the materials input structure (A). In that case, the post-technical-change paths (shock and final) result from superimposing the impact of CBA on the historical trends. Alternatively, the evolutionary reference path (E) subtracts the impact of CBA on 1/Q and A from the historical trends (for out-of-sample simulations) so that the reference path contains all the sources of productivity improvement except those due to CBA. Then the post-technical-change paths will add the productivity improvements due to CBA such that the total effect will approximate historical trends. Both the R and the E reference paths allow the structure of final demand across commodities (FDSTR), and weekly working hours by sector (HW) to evolve according to historical rates of change.

Results are also reported using some other choices for the reference path. For example, one extreme version (B), which is often used in input/output based models, holds the supply-side structure (1/Q, A), plus the structure of final demand across sectors (FDSTR) and weekly working hours (HW), constant at base-year (1981) levels. In this case, CBA will be the only source of increased productivity out of sample. This is clearly unrealistic – these results emphasize the importance of incorporating the substitution and income effects for both demand and supply processes. Other choices for the reference path (RH or EH) are the same as R and E except that the sectoral average weekly working hours are decreased relative to historical trends. These reference paths allow us to evaluate the potential impact on the level of (un)employment of allowing a faster decrease in the length of the working week -- a "policy" which is sometimes proposed as a solution to high rates of unemployment.

TABLE 1

Employment and Displacement of Workers: Alternative Reference Paths

Scenario 000

Reference Path	B	R	RH	E	EH
TE	13753.	12526.	12846.	12692.	13075.
CEM	10246.	9019.	9338.	9185.	9568.
E	9036.	8058.	8344.	8214.	8557.
SE	1216.	961.	994.	971.	1011.
CUMULATIVE DISPLACEMENT (CBA)					
level	411.	350.	355.	351.	357.
% of (1981) CEM	5.1	4.4	4.4	4.4	4.4
% of (1995(ref))	4.0	3.9	3.8	3.8	3.7
UR(ref)	2.0	10.7	8.4	9.5	6.8
UR(shock)	4.0	12.6	10.4	11.4	8.8
UR(final)	1.6	10.5	8.2	9.3	6.6

KEY:

B reference path which keeps labour productivity (1/Q), inter-industry inputs (A), allocation of demand across sectors (FDSTR), and average weekly working hours by industry (HW) fixed at base-year (1981) levels.

R reference path which allows Q, A, FDSTR, and HW to evolve according to their historical rates of change.

RH reference path which is the same as R except that HW is decreased by 5%--for example, from 40 hours/week to 38--that is, relative to the HW along path R, for each sector I and date t, HW'(I,t)=HW(I,t)x(.95)

E reference path which allows Q, A, FDSTR, and HW to evolve as in R but subtracts the impact of CBA on Q and A from the historical trends so that the reference path contains all the sources of productivity improvement except those due to CBA.

EH reference path makes the same adjustment to HW for E as in RH.

TE is total employment or CEM+EH where EH is 'hidden employment', that is, employment not covered by commercial employment CEM from the input/output-based supply side of the model; CEM is further disaggregated into employees E and self-employed SE.

UR(ref) is the unemployment rate for the reference (or baseline) path solution in 1995.

UR(shock) is that for the solution incorporating CBA but keeping final demand at reference path levels.

UR(final) is that for solution with displaced workers re-employed using the new technological/occupational structure.

Scenario 000 is defined in the key to table 2.

Table items are in thousands of workers for the first five rows and percentages for the last five.

Table 1 reports that the unemployment rate (hereafter referred to as UR) for the E reference solution in 1995 is 9.5 in contrast to 10.7 for the R case. Under scenario 000 (see Section IV.2 below), the cumulative impact of CBA is to increase the UR by 1.9 percent to 11.4 and 12.6 for E and R respectively. However, when/if the appropriate structural adjustments take place such that the displaced workers are re-employed, the E (alternatively R) UR settles at 9.3 (alternatively 10.5). Allowing average weekly working hours to decrease at a faster rate decreases these unemployment rates to 6.6 and 8.2 percent respectively.

A particular choice of reference path will affect the **levels** of the variables -- particularly the unemployment rate[8] -- but will not substantially change the structural impact of CBA or the comparative scenario analysis for which the model was designed. Therefore, although in my opinion the reference path E is the most sensible baseline for the year-by-year calibration of MESIM, most of the results are reported relative to the R reference path for computational reasons.

IV.2 Alternative Scenarios

After choosing a reference path, one chooses a scenario. We have used scenario parameters [as in Bundesministerium (1981) or Schmoranz (1984)] in order to compute alternative scenarios for the post-technical-change solution paths 19xx(shock) and 19xx(final). The parameter DFscenario indicates the rate of diffusion of the new technology. This parameter allow us to compute the probable lower (DFscenario=0) and upper (DFscenario=2) bounds for the rate of adoption. Parameter IMscenario captures different degrees of dependence on foreign production of new CBA equipment. For example, if IMscenario equals 0, the same fraction of investment is imported as for the reference solution path 19xx(ref). On the other hand, when IMscenario equals 1 all the investment related to the new technology equipment is imported. Finally, EXscenario allows us to perturb the export path. Therefore, (DFscenario IMscenario EXscenario) equal to 000 is an example of a particular scenario choice.

Table 2 reports the implications for displacement and (un)employment of some alternative scenarios. Appendix B.2 discusses in some detail the implications (for final demand feedback and the level of imports) of the investment requirements to embody the new CBA technology in the capital stock. Since a high proportion of machinery and equipment investment is already imported (along the reference path), importing all the new CBA equipment

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8 Also, the level of (un)employment predicted for 1995 is sensitive to the extrapolation of EH (the non-commercial employment) out of sample.

TABLE 2
Displacement of Workers for some Alternative Scenarios
Relative to Reference Path R

SCENARIO	000	010	001	200	211
CEM	-3.0	-3.2	-0.7	-7.2	-5.2
E	-3.1	-3.3	-0.8	-7.4	-5.4
SE	-2.3	-2.5	0.4	-5.4	-3.0
CUMULATIVE DISPLACEMENT (CBA)					
level	350.	350.	354.	857.	864.
% of (1981) CEM	4.4	4.4	4.4	10.7	10.7
% of (1995(ref)) CEM	3.9	3.9	3.9	9.5	9.6
CUMULATIVE OCCUP SHIFTS (CBA)					
level	471.			979.	
% of (1981) CEM	5.9			12.2	
% of (1995(ref)) CEM	5.2			10.9	
UR(shock)-UR(ref)	+1.9	+1.9	+0.4	+4.6	+3.3
UR(final)-UR(ref)	-0.2	0.0	-1.7	-0.5	-1.8

KEY:

Scenarios are labelled by the setting of scenario parameters (DFscenario,IMscenario,EXscenario) where:

- DFscenario indicates the rate of adoption or diffusion--
  - 0 and 2 are similar to scenarios 2 and 3 in Leontief and Duchin (1986).
- IMscenario indicates the fraction of CBA equipment which is imported--
  - 0 implies that the same fraction is imported as for machinery and equipment investment along the reference path, while
  - 1 implies that all new CBA equipment is imported.
- EXscenario indicates the level of exports--
  - 0 and 1 imply empirically observed and a shift (increase) in the export function by 5 percent, respectively.

Table items in the first three rows are percentage displacement relative to their common reference path solution, that is, [(1995(shock)/1995(ref))-1]x100.

See Table 1 for key to variable definitions.

OCCUP SHIFTS measures displacement by adding the jobs created for computer professionals to those lost for draughtsmen-related activities--rather than subtracting the former from the latter when interpreting displacement as NET loss of jobs.

which is required by the rate of diffusion 0--that is, scenario 010--does not change the results a great deal relative to scenario 000. Essentially, the displacement of workers due to the application of CBA is the same but the final demand level is lower since imports are higher relative to the 000 scenario. The net effect is a 1995(final) UR which is .2 percent higher for scenario 010 relative to 000. On the other hand, comparing scenario 001 with 000--that is, increasing exports by 5 percent for the former relative to the latter--results in a 1.5 percent decrease in the UR. The extra final demand due to higher exports, presumably brought about by improved competitiveness due to the adoption of CBA, almost completely offsets the displacement due to the CBA.

A much faster rate of diffusion of the known CBA technology, indicated by a DFscenario setting of 2 rather than 0,[9] results in more than twice the cumulative displacement (4.4 to 10.7 percent of the base-year commercial employment for scenario 000 versus 200). Of course, in the unlikely event that we were able to achieve such a fast rate of diffusion, we may have to import more equipment and, since we would probably be adopting CBA at a faster rate than our trading partners, we would be able to increase our exports -- resulting in a scenario such as 211.

Although the cumulative displacement of workers increases as the rate of diffusion of the new technology increases, from the viewpoint of output per employed worker, a faster rate of diffusion is beneficial. Table 3 illustrates some benefits of technical progress and costs of higher imports by computing the changes in levels of income and final demand when all the structural adjustments have taken place--that is, when the displaced workers are re-employed using the new technological/occupational structure and the solution 1995(final) is attained. For example, under scenario 000 (alternatively 200), GDP is 3.8 (alternatively 9.7) percent higher by 1995 than it would have been without the adoption of CBA from 1982 to 1995. As another example, wages per employee hour increase by 6.2 (10.1-3.9) percent when, ceteris paribus, the rate of diffusion increases from that indicated by DFscenario equal to 0 versus 2.

IV.3 Displacement by Sector and Application of CBA

Tables 4 to 10 provide a detailed account of the potential impact of the CBA modeled in this paper on the number and proportion of displaced workers by sector, occupation, appli-

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9 As discussed in Appendix B, a DFscenario equal to 2 rather than 0 implies assumptions concerning the labour productivity impact of CBA analogous to the upper bound scenario in Leontief and Duchin (1986). Also, scenario 200 assumes double the number of robots in be in place by 1995 relative to scenario 000.

TABLE 3
Change in Aggregate Variables for some Alternative Scenarios assuming Re-employment of Displaced Workers

SCENARIO	000	010	001	200	211
GDP	3.8	3.6	6.1	9.7	11.9
CONS	4.2	4.0	6.5	10.8	13.0
IVME	3.5	3.5	3.4	8.8	8.7
EX	4.0	3.8	11.4	10.1	17.7
IM	4.2	4.3	8.0	10.6	14.8
WG	3.9	3.6	7.0	10.0	12.8
WGH	3.9	3.8	5.3	10.1	11.3
PRG	5.2	5.0	8.0	13.4	16.2
PRGH	4.6	4.5	5.3	11.8	12.4

KEY:

See Table 2 for a key to scenario definitions.

GDP is gross domestic product, CONS is private sector consumption, IVME is machinery and equipment investment, EX is exports, IM is imports, WG and WGH are gross wages and same per employee hour, and PRG and PRGH are gross profits and same per self-employed hour.

Table items are percentages relative to their common reference path solution for 1995, that is, [(1995(final)/1995(ref))-1]x100.

cation (production and office) and sex. These tables are aggregated to 11 occupational groups (plus totals) with those occupations which are likely to be influenced by a particular application of CBA grouped together as indicated in Appendix A. Also, tables 5 and 7 report changes related to two components (occupations related to draughting activities and computer professionals such as software engineers) of the professionals group (see Appendix B.1a). Appendix D (tables 4d, 5d and 8d) reports the displaced workers by sector, occupation and application disaggregated to the 3-digit standard occupational classification on which MESIM is based -- that is, 80 occupations plus totals.[10]

In terms of total cumulative displacement (tables 4 and 4d), it is clear that the sectors with the highest proportion (relative to 1981 employment) of jobs affected are the metal fabricating, machinery and transportation equipment industries with displacement ranging from 12.0 to 19.6 percent. The rubber and plastics products industries have over 10 percent affected, while primary metals, electrical products, furniture and fixtures, wood, miscellaneous manufacturing, and non-metallic mineral products industries, as well as services to business management, all have between 5 and 10 percent displacement. The disaggregation of this total displacement to application shows that most of the production displacement occurs in sectors dealing with metal fabricating, machinery, transportation equipment, construction and primary metals; while that for office applications is concentrated in wholesale and retail trade, finance, insurance and real estate, and in services to business management.

With respect to the occupational implications of production applications of CBA (tables 5, 6, 7 and 5d), notice that negative displacement implies that the CBA creates jobs in that cell. This situation occurs for computer professionals. For some sectors, the displacement by computer-aided design (CAD) equipment (for example, draughtsmen-related jobs) offsets the job creation associated with other professionals such that there is net displacement. Also, the percentage displacement for machinists is quite high but note (from table 15) that they constitute a very small proportion of the total employment. For scenario 000, machinists decline by about 1 percent in proportional terms as compared to the pre-CBA reference path.

For occupational implications of office applications of CBA (tables 8, 9, 10 and 8d), clerical jobs are the hardest hit -- both in terms of absolute numbers and in terms of percent of 1981 employment. Finally, 34 percent of the cumulative displacement occurs for jobs which

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10 Notice that since displaced workers are computed before feedbacks occur -- that is, by comparing 19xx(shock) with 19xx(ref) -- only those occupations which are directly impacted by the CBA are reported for tables 4 to 10 and tables 4d, 5d and 8d.

TABLE 4
Displacement by Sector and Application of CBA
Reference Path R and Scenario 000

SECTOR	PRODUCTION	OFFICE	TOTAL	% of 1981 COMMERCIAL EMPLOYMENT IN SECTOR
1	0.404	0.688	1.092	0.2
2	0.753	0.240	0.993	1.6
3	0.065	0.099	0.164	0.5
4	1.745	0.364	2.109	3.5
5	0.382	0.989	1.371	3.6
6	0.693	0.153	0.846	4.0
7	0.951	0.377	1.328	3.4
8	6.946	2.894	9.841	4.2
9	0.195	0.093	0.288	3.3
10	5.747	1.333	7.080	11.5
11	0.937	0.191	1.128	4.3
12	2.129	0.551	2.680	4.0
13	0.465	0.120	0.585	2.9
14	3.323	0.689	4.013	4.2
15	7.150	0.758	7.908	7.0
16	3.812	0.517	4.330	8.0
17	5.700	1.304	7.004	5.4
18	1.701	1.813	3.514	3.2
19	10.782	1.210	11.992	9.7
20	29.096	2.017	31.113	19.6
21	11.153	1.854	13.007	12.0
22	22.415	2.362	24.777	13.9
23	8.505	1.561	10.066	7.9
24	3.258	0.606	3.864	7.0
25	0.461	0.437	0.898	4.2
26	1.557	1.504	3.062	3.5
27	3.873	1.128	5.001	7.5
28	18.309	5.370	23.679	3.4
29	5.138	6.127	11.265	2.4
30	-1.910	5.297	3.386	1.6
31	2.736	1.793	4.529	4.7
32	6.230	14.931	21.160	4.4
33	13.058	40.098	53.156	3.9
34	-11.189	29.134	17.945	3.2
35	-0.788	1.532	0.744	0.6
36	0.347	1.202	1.549	1.8
37	14.750	19.426	34.176	6.0
38	0.135	3.932	4.067	0.8
39	12.229	2.248	14.478	5.0
TOTAL	193.243	156.944	350.187	4.4

KEY: Entries are cumulative to 1995 and are in thousands of workers.
A negative entry implies that jobs are created.
See Appendix A for a key to the sectors.

TABLE 5
Displacement by Sector and Occupation for Production Applications
Reference Path R and Scenario 000

SECTOR	DRAFTS	COMPUTPROFS	PROCESSORS	MACHINIS	FB/ASM/R	EQPT/OPT	TOTAL
1	0.036	-0.027	0.107	0.109	0.075	0.102	0.404
2	0.308	-0.180	0.079	0.268	0.172	0.106	0.753
3	0.070	-0.175	0.097	0.022	0.030	0.020	0.065
4	0.664	-0.526	0.185	0.854	0.438	0.130	1.745
5	1.417	-2.029	0.110	0.495	0.220	0.169	0.382
6	0.133	-0.103	0.105	0.348	0.131	0.079	0.693
7	0.475	-0.241	0.032	0.471	0.128	0.086	0.951
8	0.221	-1.014	5.504	0.453	0.410	1.373	6.946
9	0.037	-0.108	0.134	0.077	0.029	0.026	0.195
10	0.615	-0.658	0.693	1.886	2.769	0.442	5.747
11	0.010	-0.074	0.071	0.053	0.836	0.042	0.937
12	0.097	-0.326	1.123	0.236	0.836	0.162	2.129
13	0.003	-0.018	0.182	0.010	0.253	0.037	0.465
14	0.023	-0.062	0.133	0.032	3.116	0.082	3.323
15	0.182	-0.269	2.073	3.503	0.979	0.682	7.150
16	0.066	-0.052	0.048	1.880	1.771	0.100	3.812
17	0.533	-1.120	2.367	1.725	1.381	0.813	5.700
18	0.107	-0.613	0.016	0.124	0.088	1.980	1.701
19	1.099	-1.549	2.573	7.201	0.800	0.658	10.782
20	1.500	-0.761	0.820	25.925	1.210	0.403	29.096
21	1.817	-3.307	0.196	10.785	1.473	0.188	11.153
22	1.747	-2.506	0.266	17.044	5.398	0.466	22.415
23	2.346	-0.066	0.190	3.458	2.375	0.203	8.505
24	0.309	-0.297	0.676	2.057	0.227	0.287	3.258
25	0.449	-0.822	0.290	0.353	0.082	0.108	0.461
26	0.495	-1.275	1.038	0.604	0.275	0.420	1.557
27	0.453	-0.545	0.166	2.301	1.277	0.222	3.873
28	5.148	-0.688	0.249	11.228	1.724	0.648	18.309
29	1.602	-3.889	0.072	2.905	2.453	1.995	5.138
30	0.902	-3.434	0.003	0.068	0.270	0.281	-1.910
31	3.312	-2.840	0.034	0.804	0.433	0.993	2.736
32	1.227	-4.303	0.757	4.240	2.796	1.513	6.230
33	0.456	-4.536	1.926	1.812	11.410	1.991	13.058
34	0.440	-12.135	0.032	0.171	0.151	0.151	-11.189
35	0.113	-1.057	0.013	0.049	0.042	0.052	-0.788
36	0.147	-0.171	0.026	0.065	0.138	0.142	0.347
37	20.634	-8.493	0.146	1.144	0.748	0.570	14.750
38	0.044	-0.170	0.150	0.031	0.047	0.033	0.135
39	0.257	-0.219	0.058	9.958	1.620	0.556	12.229
TOTAL	49.493	-60.657	22.738	114.750	48.609	18.310	193.243

See KEY to Table 4 and Appendix A for a key to occupational groupings.

TABLE 6

Displacement by Sector and Occupation for Production Applications
As a Percentage of 1981 Commercial Employment
Reference Path R and Scenario 000

SECTOR	(NET) PROFESSIONALS	PROCESSORS	MACHINIS	FB/ASM/R	EQPT/OPT	TOTAL
1	0.1	5.8	35.4	5.8	5.8	0.1
2	3.4	7.0	46.2	7.0	7.0	1.2
3	-8.1	9.7	74.2	9.7	9.7	0.2
4	2.4	5.5	36.3	5.5	5.5	2.9
5	-7.0	9.1	67.8	9.1	9.1	1.0
6	3.2	5.8	38.0	5.8	5.8	3.3
7	5.8	6.2	39.7	6.2	6.2	2.4
8	-17.7	5.4	35.0	5.4	5.4	3.0
9	-12.1	4.1	24.8	4.1	4.1	2.2
10	-1.6	9.8	74.5	9.8	9.8	9.4
11	-19.7	4.5	26.5	4.5	4.5	3.6
12	-9.9	4.3	24.3	4.3	4.3	3.1
13	-4.8	3.0	12.1	3.0	3.0	2.3
14	-2.5	4.4	26.0	4.4	4.4	3.5
15	-5.1	5.5	36.2	5.5	5.5	6.3
16	1.7	5.5	37.0	5.5	5.5	7.0
17	-9.1	5.7	37.5	5.7	5.7	4.4
18	-3.7	4.3	26.2	4.3	4.3	1.6
19	-5.3	6.3	42.6	6.3	6.3	8.7
20	11.0	6.0	39.7	6.0	6.0	18.3
21	-13.4	5.9	39.3	5.9	5.9	10.3
22	-7.0	7.0	47.6	7.0	7.0	12.6
23	14.3	4.7	29.4	4.7	4.7	6.7
24	0.4	5.7	36.9	5.7	5.7	5.9
25	-9.9	7.2	52.2	7.2	7.2	2.1
26	-6.8	5.3	32.4	5.3	5.3	1.8
27	-1.1	5.9	38.3	5.9	5.9	5.8
28	25.2	6.8	48.1	6.8	6.8	2.7
29	-16.7	6.6	44.8	6.6	6.6	1.1
30	-8.5	4.2	20.1	4.2	4.2	-0.9
31	2.8	7.1	49.2	7.1	7.1	2.8
32	-27.0	5.9	41.1	5.9	5.9	1.3
33	-12.0	6.4	45.6	6.4	6.4	1.0
34	-70.0	7.6	55.1	7.6	7.6	-2.0
35	-1.2	6.9	48.3	6.9	6.9	-0.7
36	-0.1	6.4	45.8	6.4	6.4	0.4
37	6.8	7.0	50.7	7.0	7.0	2.6
38	-2.2	4.2	29.1	4.2	4.2	0.0
39	0.4	7.2	53.3	7.2	7.2	4.2
TOTAL	-1.9	5.7	42.4	6.0	5.9	2.4

KEY: Entries are cumulative displacement rates 1982-1995 due to CBA as percentages of base-year (1981) commercial employment. A negative entry implies that jobs are created.

TABLE 7

Female Displacement by Sector and Occupation for Production Applications
Reference Path R and Scenario 000

SECTOR	DRAFTS	COMPUTPROFS	PROCESSORS	MACHINIS	FB/ASM/R	EQPT/OPT	TOTAL
1	0.007	-0.013	0.049	0.000	0.004	0.043	0.088
2	0.067	-0.036	0.004	0.007	0.001	0.005	0.048
3	0.000	-0.063	0.042	0.000	0.003	0.003	-0.016
4	0.051	-0.128	0.013	0.006	0.004	0.003	-0.051
5	0.303	-0.627	0.001	0.009	0.002	0.004	-0.307
6	0.009	-0.006	0.003	0.005	0.001	0.003	0.015
7	0.053	-0.052	0.001	0.013	0.003	0.003	0.021
8	0.069	-0.393	1.920	0.021	0.016	0.544	2.177
9	0.005	-0.020	0.067	0.001	0.002	0.009	0.063
10	0.097	-0.103	0.164	0.301	0.732	0.194	1.384
11	0.002	-0.018	0.017	0.008	0.556	0.031	0.596
12	0.013	-0.097	0.427	0.039	0.470	0.050	0.902
13	0.000	-0.006	0.105	0.003	0.201	0.027	0.330
14	0.015	-0.021	0.104	0.023	2.601	0.056	2.777
15	0.012	-0.105	0.135	0.239	0.081	0.046	0.407
16	0.007	0.000	0.008	0.210	0.383	0.022	0.629
17	0.038	-0.296	0.116	0.057	0.234	0.127	0.277
18	0.023	-0.174	0.003	0.023	0.021	0.591	0.487
19	0.056	-0.481	0.077	0.231	0.015	0.018	-0.084
20	0.111	-0.194	0.068	1.727	0.187	0.078	1.977
21	0.115	-0.689	0.007	0.319	0.179	0.016	-0.052
22	0.094	-0.427	0.026	1.309	0.556	0.053	1.610
23	0.240	-0.011	0.034	0.720	1.049	0.053	2.084
24	0.010	-0.085	0.086	0.196	0.019	0.044	0.270
25	0.038	-0.168	0.009	0.000	0.002	0.003	-0.115
26	0.077	-0.265	0.177	0.011	0.026	0.157	0.183
27	0.058	-0.112	0.042	0.531	0.604	0.109	1.232
28	0.418	-0.151	0.009	0.153	0.039	0.015	0.483
29	0.102	-0.826	0.005	0.018	0.022	0.082	-0.597
30	0.175	-0.982	0.001	0.004	0.018	0.044	-0.740
31	0.201	-0.763	0.001	0.004	0.003	0.020	-0.534
32	0.110	-1.053	0.166	0.230	0.279	0.276	0.009
33	0.049	-1.745	0.330	0.206	0.845	0.674	0.360
34	0.114	-4.270	0.005	0.013	0.037	0.023	-4.079
35	0.011	-0.341	0.007	0.004	0.009	0.008	-0.303
36	0.018	-0.023	0.008	0.002	0.017	0.015	0.036
37	2.550	-2.073	0.043	0.050	0.103	0.133	0.806
38	0.008	-0.034	0.064	0.002	0.010	0.009	0.059
39	0.026	-0.154	0.013	0.247	0.650	0.292	1.074
TOTAL	5.351	-17.007	4.357	6.939	9.983	3.882	13.506
percent of total displacement by occupational group:							
	10.8%	28.0%	19.2%	6.0%	20.5%	21.2%	7.0%

See KEY to Table 4.

TABLE 8
Displacement by Sector and Occupation for Office Applications
Reference Path R and Scenario 000

SECTOR	MGRS&ADMIN	CLERICAL	SALES	TOTAL
1	0.034	0.610	0.044	0.688
2	0.036	0.202	0.002	0.240
3	0.021	0.075	0.003	0.099
4	0.051	0.312	0.001	0.364
5	0.207	0.777	0.004	0.989
6	0.026	0.126	0.002	0.153
7	0.087	0.283	0.007	0.377
8	0.350	2.210	0.334	2.894
9	0.016	0.070	0.007	0.093
10	0.237	1.037	0.059	1.333
11	0.020	0.164	0.007	0.191
12	0.058	0.474	0.019	0.551
13	0.008	0.109	0.003	0.120
14	0.069	0.586	0.035	0.689
15	0.132	0.594	0.032	0.758
16	0.075	0.416	0.026	0.517
17	0.186	1.077	0.041	1.304
18	0.202	1.492	0.120	1.813
19	0.160	1.029	0.021	1.210
20	0.327	1.608	0.082	2.017
21	0.282	1.490	0.082	1.854
22	0.287	2.030	0.046	2.362
23	0.218	1.296	0.047	1.561
24	0.108	0.468	0.030	0.606
25	0.088	0.340	0.009	0.437
26	0.236	1.175	0.094	1.504
27	0.145	0.922	0.061	1.128
28	1.239	3.979	0.152	5.370
29	0.739	5.289	0.099	6.127
30	0.274	4.986	0.037	5.297
31	0.232	1.543	0.018	1.793
32	1.436	11.105	2.390	14.931
33	1.518	26.680	11.900	40.098
34	3.382	23.154	2.597	29.134
35	0.174	1.355	0.004	1.532
36	0.000	1.119	0.083	1.202
37	3.539	15.460	0.427	19.426
38	0.000	3.736	0.196	3.932
39	0.000	1.983	0.266	2.248
TOTAL	16.197	121.356	19.391	156.944

See KEY to Table 4.

TABLE 9

Displacement by Sector and Occupation for Office Applications
As a Percentage of 1981 Commercial Employment
Reference Path R and Scenario 000

SECTOR	MGRS&ADMIN	CLERICAL	SALES	TOTAL
1	2.2	5.7	1.3	0.1
2	2.3	6.2	1.3	0.4
3	3.6	7.9	2.0	0.3
4	2.2	6.6	1.3	0.6
5	4.0	10.2	2.2	2.6
6	2.6	7.3	1.5	0.7
7	2.4	6.5	1.4	1.0
8	2.4	7.7	1.4	1.2
9	1.8	6.1	1.0	1.1
10	5.1	13.8	2.8	2.2
11	1.9	6.9	1.1	0.7
12	1.6	6.2	1.0	0.8
13	0.9	4.9	0.6	0.6
14	2.0	7.1	1.2	0.7
15	2.6	7.6	1.5	0.7
16	2.6	7.3	1.5	1.0
17	2.5	7.7	1.4	1.0
18	2.1	6.2	1.2	1.7
19	2.7	8.2	1.5	1.0
20	2.7	8.1	1.6	1.3
21	2.6	8.2	1.5	1.7
22	3.1	10.0	1.8	1.3
23	1.9	6.5	1.1	1.2
24	2.4	7.4	1.4	1.1
25	3.2	8.6	1.8	2.0
26	2.1	6.9	1.2	1.7
27	2.6	7.9	1.5	1.7
28	3.1	7.2	1.8	0.8
29	2.8	6.6	1.6	1.3
30	1.3	4.5	0.8	2.5
31	3.1	7.5	1.7	1.9
32	3.0	8.4	1.7	3.1
33	3.3	8.4	1.8	2.9
34	3.6	8.4	2.0	5.3
35	3.2	8.0	1.8	1.3
36	0.0	7.7	1.9	1.4
37	3.8	8.6	2.1	3.4
38	0.0	8.1	2.1	0.8
39	0.0	8.8	2.1	0.8
TOTAL	3.0	7.9	1.8	2.0

See KEY to Table 6.

TABLE 10
Female Displacement by Sector and Occupation for Office Applications
Reference Path R and Scenario 000

SECTOR	MGRS&ADMIN	CLERICAL	SALES	TOTAL
1	0.011	0.570	0.024	0.605
2	0.004	0.144	0.000	0.148
3	0.002	0.063	0.001	0.066
4	0.007	0.193	0.000	0.200
5	0.038	0.597	0.001	0.636
6	0.002	0.081	0.000	0.083
7	0.012	0.230	0.000	0.242
8	0.044	1.327	0.068	1.439
9	0.002	0.047	0.001	0.049
10	0.028	0.595	0.007	0.630
11	0.003	0.110	0.002	0.115
12	0.010	0.302	0.006	0.317
13	0.002	0.074	0.002	0.077
14	0.018	0.411	0.014	0.443
15	0.013	0.372	0.004	0.389
16	0.012	0.275	0.006	0.292
17	0.021	0.602	0.005	0.627
18	0.049	1.127	0.035	1.212
19	0.016	0.505	0.001	0.522
20	0.035	0.984	0.005	1.024
21	0.040	0.899	0.007	0.947
22	0.033	0.969	0.003	1.005
23	0.026	0.831	0.005	0.862
24	0.012	0.293	0.005	0.309
25	0.009	0.221	0.001	0.230
26	0.037	0.816	0.014	0.867
27	0.031	0.684	0.013	0.727
28	0.121	3.321	0.023	3.465
29	0.098	3.148	0.021	3.266
30	0.097	3.079	0.016	3.192
31	0.024	1.009	0.002	1.035
32	0.250	7.468	0.305	8.022
33	0.464	21.160	6.179	27.803
34	1.128	20.737	0.835	22.700
35	0.064	1.249	0.003	1.316
36	0.000	0.925	0.047	0.973
37	0.999	13.196	0.138	14.333
38	0.000	3.064	0.110	3.175
39	0.000	1.761	0.132	1.893
TOTAL	3.761	93.437	8.039	105.236
percent of total displacement by occupational group:	23.2%	77.0%	41.5%	67.1%

See KEY to Table 7.

were held by females at the time of the 1981 census (our base year). Tables 10 and 7 show that this proportion is much higher for office applications of CBA than for production applications (67.1 percent versus 7 percent respectively). There are also significant differences across sectors in this regard.

It must be remembered that the displacement of jobs reported in tables 4 to 10 (and 4d, 5d and 8d) correspond to the post-technical-change path which keeps final demand **levels** equal to those along the reference path. Once the appropriate structural and economic adjustments take place, those workers should be re-employed according to the new technological/occupational/sectoral structure implicit in the displacement patterns.

IV.4 Percentage Change in Occupational Structure

Recall that a comparison of the 19xx(final) path with the 19xx(ref) path isolates the structural adjustments (occupational and sectoral) required to re-employ the workers displaced by the CBA. In particular, the sectoral/occupational employment matrix from the post-technical-change solution 1995(final) can be compared to that from 1995(ref) and/or 1981 and decomposed according to changes originating from the supply side (productivity and input changes) versus final demand changes.

The disaggregation of occupations in MESIM corresponds to the 3-digit standard occupational classification (SOC) -- from which 80 occupations are included. Notice that the occupational aggregation reported in tables 11 to 15 does not correspond to any standard classification but rather occupations which are likely to be influenced by a particular application of CBA are grouped together (see Appendix A).

Table 11 compares the occupational structure for the R reference path solution in 1995 with that for the base-year 1981. In total, increases in labour productivity decrease the required commercial employment by 14.5 percent from 1981-1995. That is, 1981 output levels could be produced with 14.5 percent fewer workers using 1995 technology. Nevertheless, increases in final demand offset this direct negative impact such that, on average, there is an net increase in employment. When the scale (growth) effect (11 percent in total)[11] is excluded, the

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11 The scale effect appears small. This reflects both the predicted increase in the unemployment rate from 7.5 (1981) to 10.7 (1995(ref)) percent, using the R reference path, and the predicted slowdown in the growth of the labour force (we use a growth rate predicted in Dungan, Crocker and Garesche (1983)) relative to the very rapid growth -- especially in participation rates -- in the 1970s. MESIM was designed to analyse the implications of alternative scenarios and the relative shifts in occupations rather than levels and rates of growth. As indicated in table 1, the evolutionary reference path (E) would result in more plausible levels.

service-related occupations (groups I to V) increase in relative terms (that is, relative to other occupational groups) over the period 1981-1995, while the ocupations related to manufacturing, construction and operating of transportation equipment (groups V1 to XI) all decline in relative terms.

Table 11 reports the cumulative effect of increased labour productivity,[12] decreased material input requirements, and increased demand predicted by the R baseline or reference path from 1981 to 1995(ref). Table 12 gives the impact of the CBA predicted by scenario 000. Therefore, adding table 11 plus table 12 gives the total predicted occupational shifts over 1981-1995 -- resulting in occupational shares as reported in the final column of table 12. According to this reference path and technical change scenario, the total increase in labour productivity is such that 17.9 (14.5 plus 3.4) percent fewer workers are required to produce a given amount of output with the 1995(final) technological/occupational structure as opposed to that in 1981. However, increases in final demand are such that 34.3 percent more workers are required. Once the impact of change in material inputs requirements and all the interaction effects are included, the net effect is a scale increase by 11.4 percent.

Comparing the occupational structure for the post-technical-change solution 1995(final) with that for the R reference path (pre-CBA) solution 1995(ref), table 12 (in the last and first columns respectively) illustrates the occupational adjustments required to accommodate the CBA (re-employ the displaced workers). For example, for this scenario, professionals increase (from 6.94 to 7.01 percent of the total) while machinists decrease (from 2.98 to 1.87 percent of the total). Some occupations (primary, personal services and construction plus transport operatives) increase not because they were directly impacted by the CBA technical change but rather due to the general increase in final demand made possible by the technical change.

In sum, relative to the R reference path, the predicted impact of this CBA on the occupational structure reinforces the historical relative decrease for processors, machinists, fabricators/assemblers, and equipment operatives, reinforces the relative increase in professionals, sales and managers/administrators, and offsets the relative increase in clerical occupations. The income effects, or feedback made possible by the CBA, reinforce the relative increase in personal service occupations and partially offset the relative decrease in primary and construction trades/transport operatives occupational groups.

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12 However, notice that -- reflecting historical trends -- the personal service occupations are predicted to have a fall in output per person employed.

TABLE 11
Percentage Change in Occupational Structure
Reference Path R

OCCUPATION	1981 CEM as % of total	DQ	DA	DY	inter	net	1995(ref) CEM as % of total
Mgrs & Admin	6.76	-18.9	8.4	33.0	-7.6	14.9	6.94
Professionals	7.35	-22.4	13.3	36.1	-11.0	16.0	7.68
Clerical	19.18	-17.1	6.9	32.6	-9.1	13.3	19.58
Sales	13.31	-3.3	-1.7	29.3	-2.5	21.8	14.59
Services	10.48	16.2	2.3	31.7	3.8	54.0	14.54
Primary	8.08	-31.1	-4.1	17.7	-5.8	-23.3	5.59
Processors	4.98	-27.7	-5.8	26.8	-7.7	-14.4	3.85
Machinists	3.36	-17.9	-8.6	34.1	-9.0	-1.4	2.98
Fabricators, Assemblers, Repairers	10.01	-20.6	-3.8	30.2	-6.8	-1.0	8.92
Construction, Transport Operatives	12.63	-15.7	-1.3	30.5	-7.4	6.1	12.06
Equipment Operatives	3.87	-26.1	-0.2	30.2	-10.4	-6.5	3.27
TOTAL	100.00	-14.5	1.4	30.3	-6.2	11.0	100.00

KEY:
Changes are calculated according to [(1995(ref)/1981)-1]x100.
DQ =percent change in CEM due to labour productivity (1/Q) changes.
DA =percent change in CEM due to material input changes.
DY =percent change in CEM due to final demand changes.
inter =percent change in CEM due to second and third-order interaction effects -- such as DQxDY.
net =DQ + DY + DA + inter.
See Table 1 for a definition of Reference Path R.

TABLE 12

Percentage Change in Occupational Structure Specifically Due to CBA

Reference Path R and Scenario 000

OCCUPATION	1995(ref) CEM as % of total	DQ	DA	DY	inter	net	1995(final) CEM as % of total
Mgrs & Admin	6.94	-2.3	-0.1	3.9	-0.1	1.4	7.01
Professionals	7.68	2.0	-0.1	3.9	0.1	5.9	8.10
Clerical	19.58	-7.3	-0.1	4.0	-0.3	-3.7	18.80
Sales	14.59	-1.5	-0.1	4.1	-0.1	2.4	14.91
Services	14.54	0.3	-0.1	4.1	0.0	4.3	15.13
Primary	5.59	0.2	-0.1	4.0	0.0	4.1	5.80
Processors	3.85	-4.5	-0.3	3.9	-0.2	-1.1	3.80
Machinists	2.98	-39.0	-0.3	3.8	-1.4	-36.9	1.87
Fabricators, Assemblers, Repairers	8.92	-4.5	-0.1	3.9	-0.2	-0.9	8.82
Construction, Transport Operatives	12.06	0.9	-0.1	3.7	0.0	4.5	12.57
Equipment Operatives	3.27	-5.2	-0.2	3.9	-0.2	-1.7	3.20
TOTAL	100.00	-3.4	-0.1	4.0	-0.1	0.4	100.00

KEY:

Changes are calculated according to [(1995(final)/1995(ref))-1]x100.
See Table 11 for key to column headings.

TABLE 13
Percentage Change in Occupational Structure Due to CBA
Reference Path R and Scenario 200

OCCUPATION	1995(ref) CEM as % of total	DQ	DA	DY	inter	net	1995(final) CEM as % of total
Mgrs & Admin	6.94	-8.2	-0.1	9.9	-0.8	0.8	6.94
Professionals	7.68	-10.9	-0.1	9.9	-1.0	-2.1	7.46
Clerical	19.58	-13.1	-0.1	10.1	-1.3	-4.4	18.57
Sales	14.59	-4.7	-0.1	10.4	-0.5	5.1	15.22
Services	14.54	0.9	-0.1	10.4	0.1	11.3	16.06
Primary	5.59	-0.0	-0.1	10.2	0.0	10.1	6.10
Processors	3.85	-8.1	-0.3	10.0	-0.8	0.8	3.84
Machinists	2.98	-90.3	-0.3	9.5	-8.6	-89.7	0.32
Fabricators, Assemblers, Repairers	8.92	-7.9	-0.1	9.9	-0.8	1.1	8.95
Construction, Transport Operatives	12.06	2.0	-0.1	9.5	0.2	11.6	13.35
Equipment Operatives	3.27	-9.9	-0.2	10.0	-1.0	-1.1	3.20
TOTAL	100.00	-8.3	-0.1	10.1	-0.8	0.9	100.00

KEY:
Changes are calculated according to [(1995(final)/1995(ref))-1]x100.
See Table 11 for key to column headings.

TABLE 14
Percentage Change in Occupational Structure
Reference Path E and Scenario 000

OCCUPATION	1981 CEM as % of total	DQ	DA	DY	inter	net	1995(final) CEM as % of total
Mgrs & Admin	6.76	-17.3	8.4	36.0	-8.5	18.6	7.07
Professionals	7.35	-17.1	13.3	39.2	-9.7	25.7	8.15
Clerical	19.18	-20.1	6.9	35.4	-10.7	11.4	18.87
Sales	13.31	-1.2	-1.7	31.7	-2.2	26.6	14.85
Services	10.48	18.6	2.3	34.1	5.0	59.9	14.79
Primary	8.08	-30.3	-4.1	20.2	-6.5	-20.7	5.65
Processors	4.98	-27.3	-5.8	29.7	-8.7	-12.1	3.86
Machinists	3.36	-45.2	-8.6	38.1	-16.8	-32.5	2.00
Fabricators, Assemblers, Repairers	10.01	-20.4	-3.8	33.3	-7.5	1.6	8.96
Construction, Transport Operatives	12.63	-12.6	-1.3	34.0	-7.1	13.0	12.57
Equipment Operatives	3.87	-26.8	-0.2	33.1	-11.5	-5.4	3.23
TOTAL	100.00	-14.5	1.4	33.2	-6.7	13.4	100.00

KEY:
Changes are calculated according to [(1995(final)/1981)-1]x100.
See Table 11 for key to column headings.
See Table 1 for a definition of Reference Path E.

TABLE 15
Summary of Percentage Change in Occupational Structure
Reference Path E versus R and Scenario 000 versus 200

Reference Path Scenario Solution OCCUPATION	 1981 CEM as % of total	R 1995(ref) CEM as % of total	R 000 1995(final) CEM as % of total	R 200 1995(final) CEM as % of total	E 000 1995(final) CEM as % of total
Mgrs & Admin	6.76	6.94	7.01	6.94	7.07
Professionals	7.35	7.68	8.10	7.46	8.15
Clerical	19.18	19.58	18.80	18.57	18.87
Sales	13.31	14.59	14.91	15.22	14.85
Services	10.48	14.54	15.13	16.06	14.79
Primary	8.08	5.59	5.80	6.10	5.65
Processors	4.98	3.85	3.80	3.84	3.86
Machinists	3.36	2.98	1.87	0.32	2.00
Fabricators, Assemblers, Repairers	10.01	8.92	8.82	8.95	8.96
Construction, Transport Operatives	12.63	12.06	12.57	13.35	12.57
Equipment Operatives	3.87	3.27	3.20	3.20	3.23
TOTAL	100.00	100.00	100.00	100.00	100.00

KEY: See Table 1 for reference path definitions and Table 2 for a key to scenario definitions.

It is my opinion that the rates of adoption of CBA inherent in the scenario 200 are unrealistically high. Nevertheless, it may be interesting to determine the implications for occupational structure if we were to substantially increase the rate of adoption. Table 13 reports the occupational shifts required to accommodate the structural change initiated by CBA for scenario 200 relative to the reference path R. Notice that at these faster rates of diffusion the new technology partially offsets the relative increase in managers/administrators and professionals rather than re-inforcing those trends as in 000. Leontief and Duchin (1986, chapter 3) discuss the increasing automation of information processing and software engineering associated with faster rates of diffusion.

Table 14 sums the E (evolutionary) reference path changes and the CBA induced changes for scenario 000. These total occupational changes can be compared to those using the R reference path (the sum of tables 11 and 12). Finally, table 15 summarizes the occupational changes by comparing the net relative changes for different reference paths (E versus R) and alternative scenarios with respect to the rate of adoption of CBA (000 versus 200).

V. CONCLUDING COMMENTS

Our strategy has been: (i) to attempt to base our model in the actual data at a disaggregated level -- for example, our simulation model is calibrated on an annual basis to a reference or baseline path which incorporates detailed sectoral trends for both supply and demand; (ii) to compile and adapt as much information as possible at a disaggregated level concerning the labour productivity **impacts** of CBA, and then utilizing this sectoral and occupational information (iii) to simulate the **net** effects of CBA when the interdependencies of the economy are explicitly modeled.

Without detailed information concerning the appropriate elasticities, it is difficult to predict the speed and extent of the economy's response to the introduction of the new technology. Therefore, the probable upper and lower bounds of the feasible outcomes are computed by solving for two post-technical-change paths -- one which keeps final demand **levels** equal to those along the reference path so that the potential number of displaced workers can be computed, and the other which computes the final demand and income made possible when/if all the displaced workers are re-employed using the new technological/occupational structure. Additional structure on the model provided by, for example, a theory of skill acquisition, could predict a particular transition between these two extreme post-technical-change paths.

Finally, uncertainty concerning Canada's rate of adoption of the new technology (relative to other countries) has been modeled by comparing alternative **scenarios** which are determined by different diffusion rates, different degrees of dependence on foreign production of the required new equipment, and different degrees of success in export markets.

Modeling potential sources of future structural change is difficult and our results are, of course, subject to the usual caveat that the predictions are conditional. In particular, they are conditional on the information available about the impact of the computer-based automation and on assumptions, for example, concerning the model's structure and the future path of exogenous variables such as the labour supply.

Nevertheless, computing the feasible range of results gives some indication of the probable numbers of new jobs required to prevent technological unemployment. The aggregate results indicate that application of available computer-based automation technologies, at historically projected rates of diffusion, does not seriously threaten the total number of jobs available. That is, the magnitude of absorption or new job creation required to prevent technological unemployment will be relatively small. For example, the aggregate results for a plausible scenario 000 indicate that the CBA modeled in this paper initiates a quarter of one percent (alternatively, 0.6 of one percent for scenario 200) average yearly increase in labour productivity and consequently results in a cumulative displacement of 4.4 percent (alternatively, 10.7 for scenario 200) of the base-year commercial employment from 1981-1995.[13] Of course, these calculations of CBA-initiated displacement of workers refer to only one component of the potential applications of microelectronics-based technical change. Also, the impact of CBA on non-commercial employment was not included in our model.

A further benefit of the disaggregative approach adopted here is that computing the potential size of the displacement or dislocations at a disaggregated level of detail provides an indication of the magnitude and location of possible structural unemployment (occupational and sectoral mismatches between lay-offs and new job vacancies) initiated by the CBA. The results show that the impact of the new technology will be more severe for some occupations and sectors than others. The matching of the skills and the location of the displaced workers and those required by the new technology will be an important issue. In addition, the impli-

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13 This compares with the new job creation associated with an increase in employment of 48 percent over the previous 14 year period (1967-1981) which to a large extent accommodated the demographic (baby boom) and female participation rate changes.

cations for displacement of females versus males are clearly different for office than for production applications.

The occupational adjustments required to accommodate the CBA will for the most part follow (re-inforce) historical trends. That is, the manufacturing occupations continue to decline in proportional terms while the service sector, manager/administration and professional groups continue to increase. However, the CBA offsets the historical proportional increase in clerical occupations. At considerably faster rates of adoption, the historical increase in manager/administrators and professionals is also partially offset in proportional terms. If all the appropriate economic and structural adjustments were to take place, the displaced workers should be re-employed and national income would improve accordingly. Overall, these results highlight the importance of facilitating the structural adjustments required by technical change.

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APPENDIX A--Sectoral and Occupational Classification

Sectors

1. Agriculture.
2. Forestry.
3. Fishing, Hunting and Trapping.
4. Metal Mines.
5. Mineral Fuels.
6. Non-Metal Mines and Quarries.
7. Services Incidental to Mining.
8. Food and Beverage Industries.
9. Tobacco Products Industries.
10. Rubber and Plastics Products Industries.
11. Leather Industries.
12. Textile Industries.
13. Knitting Mills.
14. Clothing Industries.
15. Wood Industries.
16. Furniture and Fixture Industries.
17. Paper and Allied Industries.
18. Printing and Publishing.
19. Primary Metal Industries.
20. Metal Fabricating Industries.
21. Machinery Industries.
22. Transportation Equipment Industries.
23. Electrical Products Industries.
24. Non-Metallic Mineral Product Industries.
25. Petroleum and Coal Products Industries.
26. Chemical and Chemical Products Industries.
27. Miscellaneous Manufacturing Industries.
28. Construction Industry.
29. Transportation and Storage.
30. Communication.
31. Electrical Power, Gas, and Other Utilities.
32. Wholesale Trade.
33. Retail Trade.
34. Finance, Insurance and Real Estate.
35. Education and Health Services.
36. Amusement and Recreation Services.
37. Services to Business Management.
38. Accommodation and Food Services.
39. Other Personal and Miscellaneous Services.

Details concerning the spreading of the inputs and outputs associated with the "dummy" industries over the other industries (to ensure appropriate productivity measures), and the generation of the A, FDSTR and Q data matrices used in this study are available from the author on request.

Occupational Groups (3-digit SOC)

I. Managerial, Administrative and Related Occupations

1. Officials and Administrators Unique to Government
2. Other Managers and Administrators
3. Occupations Related to Management and Administration

II. Professionals

4. Occupations in Physical Sciences
5. Occupations in Life Sciences
6. Architects and Engineers
7. Other Occupations in Architecture and Engineering
8. Occupations in Mathematics, Statistics, Systems Analysis and Related Fields
9. Occupations in Social Sciences
10. Occupations in Social Work and Related Fields
11. Occupations in Law and Jurisprudence
12. Occupations in Library, Museum and Archival Sciences
13. Other Occupations in Social Sciences and Related Fields
14. Occupations in Religion
15. University Teaching and Related Occupations
16. Elementary and Secondary School Teaching and Related Occupations
17. Other Teaching and Related Occupations
18. Health Diagnosing and Treating Occupations
19. Nursing, Therapy and Related Assisting Occupations
20. Other Occupations in Medicine and Health
21. Occupations in Fine and Commercial Art, Photography and Related Fields
22. Occupations in Performing and Audiovisual Arts
23. Occupations in Writing
24. Occupations in Sport and Recreation

III. Clerical

25. Stenographic and Typing Occupations
26. Bookkeeping, Account-Recording and Related Occupations
27. Office Machine and Electronic Data-Processing Equipment Operators
28. Material Recording, Scheduling and Distributing Occupations
29. Library, File and Correspondence Clerks and Related Occupations
30. Reception, Information, Mail and Message Distribution Occupations
31. Other Clerical and Related Occupations

IV. Sales Occupations

32. Sales Occupations, Commodities
33. Sales Occupations, Services
34. Other Sales Occupations

V.**Service Occupations**

35. Protective Service Occupations
36. Food and Beverage Preparation and Related Service Occupations
37. Occupations in Lodging and Other Accommodation
38. Personal Service Occupations
39. Apparel and Furnishing Service Occupations
40. Other Service Occupations

VI.**Primary**

41. Farmers
42. Farm Management Occupations
43. Other Farming, Horticultural and Animal-Husbandry Occupations
44. Fishing, Hunting, Trapping and Related Occupations
45. Forestry and Logging Occupations
46. Mining and Quarrying Including Oil and Gas Field Occupations

VII.**Processing Occupations**

47. Mineral Ore Treating Occupations
48. Metal Processing and Related Occupations
49. Clay, Glass and Stone Processing, Forming and Related Occupations
50. Chemicals, Petroleum, Rubber, Plastic and Related Materials Processing Occupations
51. Food, Beverage and Related Processing Occupations
52. Wood Processing Occupations, Except Paper Pulp
53. Pulp and Papermaking and Related Occupations
54. Textile Processing Occupations
55. Other Processing Occupations

VIII.**Machining and Related Occupations**

56. Metal Machining Occupations
57. Metal Shaping and Forming Occupations, Except Machining
58. Wood Machining Occupations
59. Clay, Glass, Stone and Related Material Machining Occupations
60. Other Machining and Related Occupations

IX.**Product Fabricating, Assembling and Repairing Occupations**

61. Fabricating, and Assembling Occupations, Metal Products, n.e.c.
62. Fabricating, Assembling, Installing and Repairing Occupations: Electrical, Electronic and Related Equipment
63. Fabricating, Assembling and Repairing Occupations: Wood Products
64. Fabricating, Assembling and Repairing Occupations: Textile, Fur and Leather Products
65. Fabricating, Assembling and Repairing Occupations: Rubber, Plastic and Related Products
66. Mechanics and Repairmen, n.e.c. (not elsewhere included)
67. Other Product Fabricating, Assembling and Repairing Occupations

X.Construction Trades and Transport Equipment Operatives

68. Excavating, Grading, Paving and Related Occupations
69. Electrical Power, Lighting and Wire Communications Equipment Erecting, Installing and Repairing Occupations
70. Other Construction Trades Occupations
71. Air Transport Operating Occupations
72. Railway Transport Operating Occupations
73. Water Transport Operating Occupations
74. Motor Transport Operating Occupations
75. Other Transport Equipment Operating Occupations

XI.Material-Handling, Equipment Operatives and Crafts

76. Material-Handling and Related Occupations, n.e.c.
77. Printing and Related Occupations
78. Stationary Engine and Utilities Equipment Operating Occupations
79. Electronic and Related Communications Equipment Operating Occupations, n.e.c.
80. Other Crafts and Equipment Operating Occupations, n.e.c.

APPENDIX B--Computer-Based Automation Data

Appendix B.1: Sources and Incorporation of CBA Impact Data

CBA shocks modeled in this project are those related to the introduction of programmable or computer-based automation (CBA) in production processes and office applications.

Appendix B.1a: Production Applications

1. Impact on labour input coefficients

   a. robots

   - the displacement rate per robot was assumed to be 2.67 computed on the basis of each robot displacing 1.5 workers but requiring 1/6 of a robot technician per shift with two shifts per day [cf. Leontief and Duchin (1986, p.59) and Hunt and Hunt (1983)].
   - the number of robots was projected to be 16000 by 1995 [see Appendix B.4], for the rate of adoption scenario indicated by DFscenario=0, and twice that number for the accelerated rate of adoption scenario (DFscenario=2)
   - on the basis of the above, the predicted number of workers displaced by robots between 1981 and 1995 can be computed for each of the rate of adoption scenarios
   - the number of potentially affected workers was proxied by the 1982 employment in the robot-affected occupational groups: VII processing; VIII machining; IX product fabricating, assembling and repairing; and XI material handling
   - the predicted proportion of those workers which will be displaced by 1995 (that is, predicted cumulative displacement as a proportion of those potentially affected) is converted to an annual proportion by dividing by 14
   - this method of predicting displacement, by sector and occupation, relies on the aggregate number of robots, the average displacement per robot, and the number plus the sectoral distribution of workers in potentially affected occupations. Due to the difficulty in compiling disaggregated (by sector and application) predictions of robot stocks it was felt that the above method would provide better projections.

   b. machine tools

   - The sectoral labour input coefficients for machinists (occupation group VIII) are reduced according to information adapted (see Appendix C) from Leontief and Duchin (1986, table 2.3) for the corresponding year and the rate of adoption scenario.

   c. CAD/CAM impact on draughtsmen

   The sectoral labour input coefficients for draughting occupations are reduced according to information adapted (see Appendix C) from Leontief and Duchin (1986, table 2.4) for the corresponding year and the rate of adoption scenario. The occupations potentially affected were chosen (on the basis of the 4-digit SOC census data for 1981) from occupational groups 6 and 7 (occupations in architecture and engineering).

d. CAD/CAM impact on computer professionals

- The labour input coefficients for occupational group 8 (occupations in mathematics, statistics, systems analysis and related fields) are adjusted (according to the year and the rate of adoption scenario) for sectors 21, 23, 33, 34, 35 and 37 using information adapted (see Appendix C) from Leontief and Duchin (1986, table 2.3).

- In the case of computer professionals, the labour input coefficient is usually increased implying job creation (for the same level of output) rather than displacement. This does not imply that computer professionals are becoming less productive but rather that more computers are being used per unit output in the various sectors.

- To proxy the increased use of computers in all sectors, the corresponding occupational labour input coefficients for the remaining sectors are adjusted, according to the year and rate of adoption scenario, by the average of the adjustment factors applied to the above sectors.

2. Impact on non-labour (material) input requirements [Leontief and Duchin (1986, ch.2)]:

- The rapid technical change in the production of computers and electronic equipment is reflected in a decrease in inputs (labour and materials) to electrical products sector 23.

- Due to the use of CNC tools, a small decrease in inputs of steel (A(19,I)) was incorporated, whereas the production of CNC tools increases inputs of electrical equipment (A(23,20)).

- The production of robots reduces the use of steel (A(19,20)), while the use of robots implies less paint use in some industries (A(26,I)).

- As expected, these changes in the structure of the A matrix due to CBA are small (except for computer production) relative to the substitution trends already incorporated in the reference path.

Appendix B.1b: Office Applications

1. The impact of CBA in offices on direct labour requirements is adapted (see Appendix C) from Leontief and Duchin (1986, tables 3.2 to 3.10) for the corresponding occupations and sectors in MESIM.

2. In particular, the following occupations and sectors have their direct labour requirements reduced (according to the year and rate of adoption scenario):

   a. managers (occ 1,2,3) for all sectors except 36, 38 and 39;

   b. sales workers (occ 18) for sectors 33, 36, 38 and 39 and for all other sectors;

   c. secretaries, typists and stenographers (occ 25-- using weights derived from the 4-digit SOC to implement the differential impact information provided in Leontief and Duchin's table 3.5) for all sectors;

   d. bank tellers and cashiers (occ 26--averaging the differential impact information provided in Leontief and Duchin's tables 3.7 and 3.9 since the Canadian 4-digit SOC does not distinquish these two occupations) for all sectors; office machine operators (occ 27) for all sectors;

e. telephone operators (occ 30) for all sectors;

f. clerical workers who manipulate data (occ 28 and 29) for all sectors;

g. clerical workers who interact with the public (occ 31) for all sectors.

Appendix B.2: Investment Implications of CBA

- Investment Feedback to Final Demand

  - The following stock and price estimates related to CBA technical change, are combined to derive estimates of the feedback to final demand due to investment requirements to embody the new technology in the capital stock.

  - Appendix B.4 provides sources for the prediction of 16,000 robots by 1995.

  - Based upon estimates of 1984 machine tool stocks and predictions of the annual increase in the installed base [Canadian Machinery and Metalworking (1985), Ontario Ministry of Industry, Trade and Technology (1985), Leontief and Duchin (1986), and industry experts], we estimated the the 1995 stock of NC/CNC machine tools to be 40.000 which implies an average annual rate of increase of 22 percent. This estimate is consistent with assuming a constant stock of total machine tools but a rapid increase (an industry expert predicts 80 percent by 1995) in the proportion of that stock which consist of the NC/CNC type.

  - Although some industry estimates exist for stocks of CAD equipment (for example, it used to be possible to use the number of high resolution display terminals to arrive at an approximation), it is very difficult to find a comprehensive estimate given the diversity of the equipment that is now available and the overlap in function that PC CAD allows. The data problem for stocks of CAM related equipment is even more problematic. This project attempted to estimate the implications of the diffusion of **currently** available new technology (essentially automation of particular functions such as designing, welding, painting, loading, machining, etc.) rather than the more comprehensive computer integrated manufacturing (CIM). Therefore, it was decided to approximate the number of computers that are used in production by twice the sum of robots and numerically controlled machine tools in place. This approximation reflects the fact that currently the main role of computers in production is to control inventories and equipment such as robots and machine tools and to aid design. Given the more detailed data for the impact of CBA technology in offices, it was possible to estimate the number of newly equipped work places (by sector) each year (see Appendix C). The aggregate of these sectoral estimates serves as the stock estimate for new investment in computer-related office equipment.

  - Price indices for converting current$ information to constant 1971$ and for projections of prices of new CBA equipment were obtained from table 4 in U.S. Department of Commerce (1985). In short, using current price data from ERC (1985), we approximated the (constant 1971$) price of robots to be $66,000 and that for computers to be $7,000. Recall that the use of computers in production will involve a multiple of the individual computer investment cost. Also, based on consultation with industry experts and the IT&T Report (1985), we chose an average price of $134,000 for 1982 (in constant 1971$) for a "typical" CNC system.

- Recall that estimates and projections of NC/CNC machine tools and computer stocks, and the associated price estimates, only affect the investment feedback to aggregate demand, since the disaggregated impact on productivity, and consequently on employment, was implemented as described in Appendices B.1 and C.

- The size of the investment feedback is influenced by the relatively rapid rate of deflation for such equipment. Therefore, although the number of machines projected to be use by 1995 appears to be large, the cost of those machines (in constant dollars) has been predicted to fall considerably.

- Of course, the size of the investment feedback will also depend on the rate of adoption scenario, and the effect on **domestic** production will depend on the assumption concerning the proportion of new technology equipment which is imported (controlled by the setting of the second scenario parameter--that is, IMscenario).

- Structure of Investment

  - The impact of the introduction of CBA technology on the aggregate level of investment is uncertain. While new machines must be produced (or imported), those using the old technology which is being replaced no longer need to be produced (or imported). Therefore, the net effect of CBA on the level of machinery and equipment investment (IVME) depends on whether the (constant price) cost of the new technology is greater or less than that of the old technology it is replacing.

  - An estimate is incorporated by assuming that the aggregate **level** of IVME for the post-technical-change path 19xx(shock) is equal to that for the pre-technical-change path 19xx(ref), but that its structure across sectors changes. In particular, the IVME required to embody the new technology (see below) is subtracted from all the manufacturing sectors (according to the proportion of machinery and equipment investment in each sector along 19xx(ref)) and added back into the sectors which would produce the new equipment (20 to 23 inclusive)--again according to their relative shares of investment. That is, there is a change in the sectoral structure of required investment.

  - Of course, since the structure has changed, there will still be employment consequences.

Appendix B.3: New Technology Import Assumptions

- Recall that IMscenario captures different degrees of dependence on foreign production of new equipment. IMscenario equal to 0 implies that the same fraction of investment is imported as for the reference solution path 19xx(ref). On the other hand, when IMscenario equals 1 all the investment related to the new technology equipment is imported.

- Given the above assumptions about the level and structure of investment, when IMscenario equals 0 we will now be importing more in sectors 20 to 23 and less in the other manufacturing sectors although the level of imports will be approximately the same (approximately since a slightly higher proportion of investment is imported in sectors 20 to 23 than in the other sectors). However, when IMscenario equals 1, imports will not only have a new structure but will also be considerably higher.

- Therefore, the international links are modeled using estimated import and export functions and separating investment which is imported from that which is domestically produced. Then the implications of faster diffusion at home relative to the rest of the world (and vice versa of course) are analysed by computing scenarios which perturb, by a chosen percentage, the fraction of investment that is imported (IMscenario parameter setting) and/or the export path (EXscenario parameter setting). Recall that EXscenario equals 0 implies that exports are at empirically observed and extrapolated levels while EXscenario equal to 1 increases exports (by five percent in this project).

Appendix B.4: Aggregate Stock Estimates and Projections for Robots

Data on aggregate stocks of new technology equipment projected to be in place in Canada have been integrated into the model. Having spent considerable time and expense collecting these stock estimates disaggregated by sector and application, it became clear that such data as is currently available is inadequate. For this reason, we have used predictions of aggregate stocks of robots to model the scale effect for robot applications (see Appendix B.1); and predictions of aggregate stocks of robots, NC/CNC machine tools and computers, plus the associated price projections, for the investment feedback to final demand (see Appendix B.3). The use of productivity impacts and very disaggregated occupational data provides a much more robust means of implementing the impact of CBA on the structure of employment than would be obtained with the limited information currently available about the disaggregated sectoral (and application) distribution of the new equipment stocks.

Quantitative estimates of the total installed base of robots [ERC (1985b)]:

Year	Units Installed	Implied Annual Rate of Increase
1983	700	
1984	940	34%
1985	1290	37%
1986	1800	40%
1987	2520	40%
1988	3535	40%
1989	4950	40%
1990	6930	40%

Estimating a total for 1995:

A possible rule of thumb for estimating total Canadian robot installations is that it be about 10% of that in the U.S.. Hunt and Hunt (1984, p.8) provide the following summary of forecasts for the U.S.:

Forecast Year	1990	1995	2000
OECD	56,000		
Delphi forecast	53,300	120,000	
Hunt & Hunt	50K-100K		
Leontief and Duchin	72K-130K	138K-268K (simple interpolation)	204K-406K
Implied Canadian	5000-10,000	12,000-27,000	

The implied Canadian forecast for 1990 compares with the 6930 projected by ERC for that date. To gauge the relative reasonableness of these predictions, the next chart shows the average annual growth rate implied by each forecast over the period from 1985 to the forecast date (based on 1290 robots installed in 1985).

	1990	1995	implied avg. rate
Delphi	5330		32.8%
Hunt & Hunt LOW	5000		31.1%
Hunt & Hunt HIGH	10000		50.6%
ERC	6930		40.0%
OECD	5600		34.1%
Delphi		12000	25.0%
ERC trend cont'd		37300	40.0%
ERC 1990 then 25%	6930	21100	40% to 90, then 25%
Delphi 1990 then 25%	5300	16000	32.8% to 90, then 25%

We chose an estimated aggregate stock of 16,000 for the base rate of adoption scenario.

APPENDIX C--Incorporating the Labour Productivity Impacts of CBA

In tables 2.3, 2.4, 2.8 and 3.2 to 3.10, Leontief and Duchin (1986) provide data for:

γ_{kj} ≡ proportion of time saved by the new technology relative to the old technology for affected workers of occupation k in section j

μ_{kj} ≡ proportion of workers of occupation k in sector j who are not affected by the new technology

ω_{kj} ≡ proportion of time spent on tasks potentially affected

Q^{τ} / Q^{t} ≡ labour input coefficients at time τ relative to those at time t.

In our model (suppressing the occupational and sectoral subscripts):

$$Q^{\tau} = Q^{t} - DQ = Q^{t}(1 - DF\, S\, \gamma)$$

where:

DQ ≡ the change in labour input coefficients

S ≡ the proportion of workers' hours potentially affected by CBA

DF ≡ the rate of diffusion of the new technology.

Since the Leontief and Duchin (1986, p. 74) equation (3-2') reduces to:

$$Q^{\tau} = Q^{t}(1 - \gamma\omega(1 - \mu)),$$

our shock data can be calculated using the following formulae:

$$S_{kj} \equiv \omega_{kj}(1 - \mu_{kj}),$$

$$DF_{kj}^{\tau,\tau+1} = (\omega_{kj}^{\tau}(1 - \mu_{kj}^{\tau})\, \gamma_{kj}^{\tau}) / (\omega_{kj}^{\tau+1}(1 - \mu_{kj}^{\tau+1})\, \gamma_{kj}^{\tau+1})$$

APPENDIX D--Displacement of Workers: 39 Sectors by 80 Occupations

TABLE 4d

Total Displacement by [39 Sectors]/(80 Occupations)

Reference Path R and Scenario 000

[1] TOTAL 1.092										
(2) 0.023	(3) 0.011	(7) 0.036	(8) -0.027	(25) 0.086	(26) 0.379	(27) 0.009	(28) 0.047	(29) 0.001	(30) 0.064	(31) 0.023
(32) 0.040	(34) 0.003	(49) 0.001	(50) 0.002	(51) 0.088	(52) 0.004	(55) 0.011	(56) 0.011	(57) 0.095	(58) 0.004	(62) 0.002
(63) 0.002	(64) 0.003	(66) 0.064	(67) 0.005	(76) 0.099	(78) 0.003					
[2] TOTAL 0.993										
(2) 0.021	(3) 0.014	(7) 0.308	(8) -0.180	(25) 0.037	(26) 0.084	(27) 0.023	(28) 0.031	(29) 0.004	(30) 0.006	(31) 0.015
(32) 0.002	(48) 0.001	(50) 0.002	(51) 0.003	(52) 0.052	(53) 0.020	(56) 0.034	(57) 0.158	(58) 0.063	(60) 0.013	(61) 0.002
(62) 0.003	(63) 0.003	(65) 0.003	(66) 0.158	(67) 0.003	(76) 0.092	(77) 0.001	(78) 0.008	(79) 0.004		
[3] TOTAL 0.164										
(2) 0.011	(3) 0.010	(7) 0.070	(8) -0.175	(25) 0.018	(26) 0.027	(27) 0.006	(28) 0.011	(29) 0.002	(30) 0.004	(31) 0.007
(32) 0.003	(51) 0.096	(56) 0.007	(57) 0.015	(62) 0.002	(64) 0.002	(66) 0.004	(67) 0.022	(76) 0.014	(78) 0.003	(79) 0.001
[4] TOTAL 2.109										
(2) 0.028	(3) 0.023	(7) 0.664	(8) -0.526	(25) 0.065	(26) 0.068	(27) 0.047	(28) 0.098	(29) 0.007	(30) 0.011	(31) 0.015
(32) 0.001	(47) 0.143	(48) 0.031	(49) 0.003	(50) 0.006	(56) 0.149	(57) 0.671	(58) 0.007	(59) 0.007	(60) 0.020	(61) 0.001
(62) 0.026	(65) 0.002	(66) 0.403	(67) 0.006	(76) 0.096	(78) 0.032					
[5] TOTAL 1.371										
(2) 0.111	(3) 0.096	(7) 1.417	(8) -2.029	(25) 0.178	(26) 0.205	(27) 0.194	(28) 0.084	(29) 0.032	(30) 0.036	(31) 0.047
(32) 0.004	(47) 0.004	(48) 0.002	(50) 0.102	(56) 0.062	(57) 0.422	(59) 0.006	(60) 0.004	(61) 0.001	(62) 0.016	(66) 0.200
(67) 0.002	(76) 0.050	(77) 0.001	(78) 0.117							
[6] TOTAL 0.846										
(2) 0.018	(3) 0.007	(7) 0.133	(8) -0.103	(25) 0.021	(26) 0.035	(27) 0.016	(28) 0.038	(29) 0.003	(30) 0.004	(31) 0.008
(32) 0.002	(47) 0.021	(48) 0.003	(49) 0.068	(50) 0.010	(51) 0.002	(56) 0.041	(57) 0.279	(59) 0.029	(62) 0.009	(66) 0.118
(67) 0.001	(76) 0.069	(78) 0.011								
[7] TOTAL 1.328										
(2) 0.067	(3) 0.021	(7) 0.475	(8) -0.241	(25) 0.079	(26) 0.107	(27) 0.026	(28) 0.040	(29) 0.006	(30) 0.012	(31) 0.013
(32) 0.007	(47) 0.008	(48) 0.003	(50) 0.019	(56) 0.071	(57) 0.382	(58) 0.002	(59) 0.010	(60) 0.006	(61) 0.002	(62) 0.004
(66) 0.114	(67) 0.007	(76) 0.054	(78) 0.030	(79) 0.001						
[8] TOTAL 9.841										
(2) 0.262	(3) 0.089	(7) 0.221	(8) -1.014	(25) 0.244	(26) 0.563	(27) 0.206	(28) 1.021	(29) 0.011	(30) 0.082	(31) 0.082
(32) 0.226	(33) 0.001	(34) 0.107	(48) 0.002	(49) 0.001	(50) 0.011	(51) 5.483	(52) 0.002	(53) 0.001	(55) 0.002	(56) 0.234
(57) 0.202	(58) 0.001	(60) 0.015	(61) 0.003	(62) 0.052	(63) 0.003	(64) 0.004	(66) 0.313	(67) 0.034	(76) 1.254	(77) 0.005
(78) 0.114										
[9] TOTAL 0.288										
(2) 0.012	(3) 0.004	(7) 0.037	(8) -0.108	(25) 0.014	(26) 0.009	(27) 0.012	(28) 0.025	(29) 0.003	(30) 0.005	(31) 0.002
(32) 0.007	(55) 0.133	(56) 0.064	(57) 0.012	(60) 0.001	(62) 0.003	(66) 0.023	(67) 0.002	(76) 0.022	(78) 0.004	
[10] TOTAL 7.080										
(2) 0.182	(3) 0.054	(7) 0.615	(8) -0.658	(25) 0.140	(26) 0.184	(27) 0.110	(28) 0.519	(29) 0.003	(30) 0.037	(31) 0.043
(32) 0.059	(47) 0.001	(48) 0.029	(49) 0.024	(50) 0.612	(51) 0.004	(52) 0.003	(54) 0.016	(55) 0.003	(56) 0.821	(57) 0.369
(58) 0.045	(59) 0.087	(60) 0.564	(61) 0.031	(62) 0.044	(63) 0.010	(64) 0.083	(65) 2.287	(66) 0.205	(67) 0.109	(76) 0.370
(77) 0.038	(78) 0.033									
[11] TOTAL 1.128										
(2) 0.016	(3) 0.004	(7) 0.010	(8) -0.074	(25) 0.016	(26) 0.033	(27) 0.014	(28) 0.087	(30) 0.005	(31) 0.007	(32) 0.007
(50) 0.003	(54) 0.003	(55) 0.064	(56) 0.036	(57) 0.004	(58) 0.009	(60) 0.003	(64) 0.798	(65) 0.014	(66) 0.012	(67) 0.009
(76) 0.039	(77) 0.002									
[12] TOTAL 2.680										
(2) 0.045	(3) 0.013	(7) 0.097	(8) -0.326	(25) 0.062	(26) 0.098	(27) 0.038	(28) 0.233	(29) 0.004	(30) 0.021	(31) 0.018
(32) 0.019	(48) 0.004	(49) 0.003	(50) 0.065	(53) 0.002	(54) 1.046	(55) 0.003	(56) 0.155	(57) 0.064	(58) 0.003	(59) 0.002
(60) 0.012	(61) 0.030	(62) 0.014	(63) 0.001	(64) 0.618	(65) 0.016	(66) 0.118	(67) 0.039	(76) 0.114	(77) 0.026	(78) 0.022
[13] TOTAL 0.585										
(2) 0.006	(3) 0.001	(7) 0.003	(8) -0.018	(25) 0.010	(26) 0.017	(27) 0.007	(28) 0.066	(30) 0.005	(31) 0.004	(32) 0.003
(50) 0.002	(54) 0.179	(56) 0.008	(60) 0.001	(62) 0.001	(64) 0.228	(66) 0.022	(67) 0.001	(76) 0.032	(77) 0.001	(78) 0.003
[14] TOTAL 4.013										
(2) 0.055	(3) 0.013	(7) 0.023	(8) -0.062	(25) 0.052	(26) 0.132	(27) 0.038	(28) 0.311	(29) 0.008	(30) 0.024	(31) 0.021
(32) 0.034	(50) 0.001	(54) 0.124	(55) 0.007	(56) 0.021	(57) 0.005	(58) 0.001	(60) 0.004	(64) 3.075	(65) 0.002	(66) 0.029
(67) 0.008	(76) 0.076	(77) 0.003	(78) 0.002							
[15] TOTAL 7.908										
(2) 0.102	(3) 0.029	(7) 0.182	(8) -0.269	(25) 0.085	(26) 0.179	(27) 0.052	(28) 0.228	(29) 0.005	(30) 0.020	(31) 0.024
(32) 0.032	(47) 0.001	(48) 0.004	(49) 0.005	(50) 0.004	(51) 0.001	(52) 1.982	(53) 0.071	(54) 0.002	(55) 0.001	(56) 0.216

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(57)  0.419 (58)  2.317 (59)  0.050 (60)  0.500 (61)  0.009 (62)  0.028 (63)  0.582 (64)  0.017 (65)  0.002 (66)  0.293 (67)  0.049
(76)  0.630 (77)  0.002 (78)  0.049
[16]  TOTAL   4.330
( 2)  0.059 ( 3)  0.016 ( 7)  0.066 ( 8) -0.052 (25)  0.059 (26)  0.109 (27)  0.027 (28)  0.177 (29)  0.005 (30)  0.018 (31)  0.021
(32)  0.026 (48)  0.018 (49)  0.001 (50)  0.002 (52)  0.020 (54)  0.005 (56)  0.216 (57)  0.568 (58)  0.940 (59)  0.009 (60)  0.147
(61)  0.038 (62)  0.035 (63)  0.885 (64)  0.584 (65)  0.002 (66)  0.016 (67)  0.210 (76)  0.090 (77)  0.003 (78)  0.008
[17]  TOTAL   7.004
( 2)  0.125 ( 3)  0.062 ( 7)  0.533 ( 8) -1.120 (25)  0.173 (26)  0.213 (27)  0.139 (28)  0.439 (29)  0.017 (30)  0.048 (31)  0.047
(32)  0.041 (47)  0.002 (48)  0.013 (49)  0.007 (50)  0.054 (51)  0.004 (52)  0.075 (53)  2.205 (54)  0.005 (55)  0.003 (56)  0.596
(57)  0.881 (58)  0.080 (59)  0.029 (60)  0.138 (61)  0.010 (62)  0.084 (63)  0.006 (64)  0.011 (65)  0.030 (66)  0.535 (67)  0.705
(76)  0.476 (77)  0.159 (78)  0.176
[18]  TOTAL   3.514
( 2)  0.163 ( 3)  0.039 ( 7)  0.107 ( 8) -0.613 (25)  0.248 (26)  0.339 (27)  0.221 (28)  0.319 (29)  0.055 (30)  0.184 (31)  0.126
(32)  0.078 (33)  0.039 (34)  0.002 (48)  0.002 (50)  0.004 (53)  0.007 (54)  0.001 (56)  0.080 (57)  0.021 (58)  0.001 (60)  0.021
(61)  0.002 (62)  0.006 (63)  0.002 (64)  0.004 (65)  0.002 (66)  0.026 (67)  0.047 (76)  0.075 (77)  1.863 (78)  0.002 (80)  0.039
[19]  TOTAL  11.992
( 2)  0.104 ( 3)  0.056 ( 7)  1.099 ( 8) -1.549 (25)  0.152 (26)  0.174 (27)  0.118 (28)  0.477 (29)  0.021 (30)  0.036 (31)  0.051
(32)  0.021 (47)  0.232 (48)  2.271 (49)  0.016 (50)  0.045 (52)  0.001 (53)  0.004 (54)  0.002 (55)  0.001 (56)  2.601 (57)  3.974
(58)  0.036 (59)  0.022 (60)  0.569 (61)  0.080 (62)  0.144 (63)  0.004 (65)  0.006 (66)  0.521 (67)  0.045 (76)  0.576 (77)  0.006
(78)  0.076
[20]  TOTAL  31.113
( 2)  0.243 ( 3)  0.084 ( 7)  1.500 ( 8) -0.761 (25)  0.215 (26)  0.405 (27)  0.130 (28)  0.709 (29)  0.016 (30)  0.069 (31)  0.064
(32)  0.082 (47)  0.012 (48)  0.749 (49)  0.020 (50)  0.017 (51)  0.011 (52)  0.003 (53)  0.002 (54)  0.006 (55)  0.002 (56) 10.189
(57) 14.342 (58)  0.065 (59)  0.153 (60)  1.176 (61)  0.510 (62)  0.105 (63)  0.032 (64)  0.013 (65)  0.020 (66)  0.365 (67)  0.166
(76)  0.346 (77)  0.024 (78)  0.033
[21]  TOTAL  13.007
( 2)  0.199 ( 3)  0.083 ( 7)  1.817 ( 8) -3.307 (25)  0.220 (26)  0.271 (27)  0.219 (28)  0.646 (29)  0.016 (30)  0.054 (31)  0.064
(32)  0.080 (47)  0.004 (48)  0.166 (49)  0.002 (50)  0.009 (51)  0.009 (53)  0.002 (54)  0.003 (55)  0.002 (56)  4.858 (57)  5.456
(58)  0.032 (59)  0.025 (60)  0.414 (61)  0.665 (62)  0.325 (63)  0.009 (64)  0.007 (65)  0.010 (66)  0.323 (67)  0.134 (76)  0.159
(77)  0.011 (78)  0.018
[22]  TOTAL  24.777
( 2)  0.182 ( 3)  0.105 ( 7)  1.747 ( 8) -2.506 (25)  0.218 (26)  0.297 (27)  0.278 (28)  1.073 (29)  0.028 (30)  0.052 (31)  0.085
(32)  0.045 (47)  0.002 (48)  0.220 (49)  0.010 (50)  0.023 (51)  0.005 (52)  0.002 (54)  0.002 (55)  0.002 (56)  5.866 (57) 10.025
(58)  0.078 (59)  0.076 (60)  0.999 (61)  3.303 (62)  0.247 (63)  0.039 (64)  0.065 (65)  0.055 (66)  0.829 (67)  0.860 (76)  0.418
(77)  0.011 (78)  0.037
[23]  TOTAL  10.066
( 2)  0.151 ( 3)  0.067 ( 7)  2.346 ( 8) -0.066 (25)  0.187 (26)  0.211 (27)  0.185 (28)  0.582 (29)  0.015 (30)  0.058 (31)  0.056
(32)  0.046 (47)  0.001 (48)  0.160 (49)  0.008 (50)  0.013 (52)  0.001 (54)  0.006 (56)  1.252 (57)  1.949 (58)  0.020 (59)  0.023
(60)  0.214 (61)  0.074 (62)  2.100 (63)  0.015 (64) -0.005 (65)  0.010 (66)  0.080 (67)  0.091 (76)  0.156 (77)  0.015 (78)  0.021
(79)  0.007 (80)  0.004
[24]  TOTAL   3.864
( 2)  0.083 ( 3)  0.025 ( 7)  0.309 ( 8) -0.297 (25)  0.068 (26)  0.123 (27)  0.047 (28)  0.185 (29)  0.003 (30)  0.018 (31)  0.024
(32)  0.030 (47)  0.012 (48)  0.018 (49)  0.601 (50)  0.033 (51)  0.001 (52)  0.002 (53)  0.003 (54)  0.005 (56)  0.200 (57)  0.417
(58)  0.009 (59)  1.316 (60)  0.115 (61)  0.013 (62)  0.020 (63)  0.007 (64)  0.001 (65)  0.011 (66)  0.136 (67)  0.038 (76)  0.259
(77)  0.004 (78)  0.024
[25]  TOTAL   0.898
( 2)  0.056 ( 3)  0.032 ( 7)  0.449 ( 8) -0.822 (25)  0.057 (26)  0.079 (27)  0.082 (28)  0.074 (29)  0.009 (30)  0.014 (31)  0.025
(32)  0.009 (48)  0.002 (49)  0.002 (50)  0.285 (56)  0.076 (57)  0.275 (59)  0.002 (62)  0.012 (63)  0.001 (66)  0.064 (67)  0.003
(76)  0.044 (78)  0.062
[26]  TOTAL   3.062
( 2)  0.172 ( 3)  0.064 ( 7)  0.495 ( 8) -1.275 (25)  0.220 (26)  0.210 (27)  0.165 (28)  0.460 (29)  0.014 (30)  0.059 (31)  0.047
(32)  0.092 (47)  0.004 (48)  0.019 (49)  0.003 (50)  0.983 (51)  0.005 (52)  0.001 (53)  0.004 (54)  0.006 (55)  0.014 (56)  0.252
(57)  0.315 (59)  0.009 (60)  0.028 (61)  0.019 (62)  0.026 (63)  0.002 (64)  0.002 (65)  0.037 (66)  0.158 (67)  0.031 (76)  0.331
(77)  0.011 (78)  0.076
[27]  TOTAL   5.001
( 2)  0.115 ( 3)  0.030 ( 7)  0.453 ( 8) -0.545 (25)  0.138 (26)  0.199 (27)  0.101 (28)  0.359 (29)  0.011 (30)  0.064 (31)  0.050
(32)  0.059 (33)  0.002 (47)  0.001 (48)  0.049 (49)  0.013 (50)  0.041 (51)  0.003 (52)  0.006 (53)  0.008 (54)  0.017 (55)  0.028
(56)  0.607 (57)  0.591 (58)  0.149 (59)  0.580 (60)  0.372 (61)  0.134 (62)  0.126 (63)  0.044 (64)  0.136 (65)  0.085 (66)  0.073
(67)  0.679 (76)  0.135 (77)  0.048 (78)  0.011 (79)  0.011 (80)  0.016
[28]  TOTAL  23.679
( 2)  0.942 ( 3)  0.296 ( 7)  5.148 ( 8) -0.688 (25)  1.002 (26)  1.893 (27)  0.174 (28)  0.400 (29)  0.038 (30)  0.231 (31)  0.242
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(32)  0.145 (33)  0.006 (34)  0.001 (47)  0.006 (48)  0.128 (49)  0.075 (50)  0.012 (51)  0.007 (52)  0.015 (53)  0.002 (54)  0.004
(55)  0.002 (56)  0.649 (57) 10.007 (58)  0.143 (59)  0.345 (60)  0.085 (61)  0.103 (62)  0.514 (63)  0.172 (64)  0.015 (65)  0.009
(66)  0.859 (67)  0.051 (76)  0.530 (77)  0.003 (78)  0.112 (79)  0.002
[29]  TOTAL  11.265
( 2)  0.549 ( 3)  0.190 ( 7)  1.602 ( 8) -3.889 (25)  0.646 (26)  1.339 (27)  0.552 (28)  1.240 (29)  0.102 (30)  0.268 (31)  1.142
(32)  0.053 (33)  0.038 (34)  0.008 (47)  0.001 (48)  0.022 (49)  0.005 (50)  0.007 (51)  0.030 (52)  0.003 (53)  0.002 (54)  0.001
(55)  0.001 (56)  1.161 (57)  1.680 (58)  0.015 (59)  0.004 (60)  0.044 (61)  0.054 (62)  0.197 (63)  0.005 (64)  0.017 (65)  0.013
(66)  2.092 (67)  0.075 (76)  1.837 (77)  0.014 (78)  0.111 (79)  0.030 (80)  0.002
[30]  TOTAL   3.386
( 1)  0.070 ( 2)  0.147 ( 3)  0.057 ( 7)  0.902 ( 8) -3.434 (25)  0.311 (26)  0.406 (27)  0.291 (28)  0.226 (29)  0.068 (30)  3.390
(31)  0.293 (32)  0.020 (33)  0.017 (48)  0.001 (56)  0.031 (57)  0.034 (60)  0.003 (62)  0.206 (64)  0.001 (66)  0.059 (67)  0.002
(76)  0.063 (77)  0.008 (78)  0.015 (79)  0.190 (80)  0.006
[31]  TOTAL   4.529
( 2)  0.143 ( 3)  0.089 ( 7)  3.312 ( 8) -2.840 (25)  0.264 (26)  0.382 (27)  0.302 (28)  0.227 (29)  0.042 (30)  0.084 (31)  0.241
(32)  0.016 (33)  0.002 (48)  0.005 (50)  0.025 (51)  0.001 (56)  0.104 (57)  0.679 (58)  0.008 (59)  0.002 (60)  0.011 (61)  0.005
(62)  0.136 (66)  0.280 (67)  0.010 (76)  0.270 (77)  0.008 (78)  0.713 (79)  0.002
[32]  TOTAL  21.160
( 2)  1.152 ( 3)  0.284 ( 7)  1.227 ( 8) -4.303 (25)  1.453 (26)  3.062 (27)  1.113 (28)  4.190 (29)  0.152 (30)  0.560 (31)  0.575
(32)  2.273 (33)  0.011 (34)  0.105 (47)  0.006 (48)  0.089 (49)  0.021 (50)  0.081 (51)  0.405 (52)  0.089 (53)  0.022 (54)  0,034
(55)  0.009 (56)  1.344 (57)  2.136 (58)  0.325 (59)  0.231 (60)  0.204 (61)  0.171 (62)  0.357 (63)  0.063 (64)  0.189 (65)  0.139
(66)  1.744 (67)  0.133 (76)  1.391 (77)  0.059 (78)  0.051 (79)  0.003 (80)  0.008
[33]  TOTAL  53.156
( 2)  1.220 ( 3)  0.298 ( 7)  0.456 ( 8) -4.536 (25)  1.312 (26) 14.734 (27)  1.055 (28)  7.284 (29)  0.178 (30)  0.983 (31)  1.133
(32) 11.713 (33)  0.013 (34)  0.174 (48)  0.023 (49)  0.023 (50)  0.015 (51)  1.828 (52)  0.004 (53)  0.001 (54)  0.023 (55)  0.006
(56)  0.385 (57)  0.736 (58)  0.029 (59)  0.415 (60)  0.247 (61)  0.161 (62)  0.952 (63)  0.140 (64)  0.918 (65)  0.141 (66)  8.372
(67)  0.726 (76)  1.864 (77)  0.062 (78)  0.038 (79)  0.002 (80)  0.025
[34]  TOTAL  17.945
( 2)  2.094 ( 3)  1.288 ( 7)  0.440 ( 8)-12.135 (25)  4.559 (26) 12.486 (27)  2.899 (28)  0.297 (29)  0.709 (30)  0.919 (31)  1.286
(32)  0.064 (33)  2.531 (34)  0.002 (48)  0.007 (49)  0.002 (50)  0.005 (51)  0.007 (52)  0.001 (54)  0.004 (55)  0.004 (56)  0.057
(57)  0.089 (58)  0.005 (59)  0.002 (60)  0.017 (61)  0.009 (62)  0.038 (63)  0.002 (64)  0.024 (65)  0.001 (66)  0.049 (67)  0.027
(76)  0.032 (77)  0.058 (78)  0.055 (79)  0.004 (80)  0.003
[35]  TOTAL   0.744
( 2)  0.142 ( 3)  0.032 ( 7)  0.113 ( 8) -1.057 (25)  0.529 (26)  0.151 (27)  0.089 (28)  0.095 (29)  0.223 (30)  0.205 (31)  0.063
(32)  0.003 (50)  0.005 (51)  0.006 (56)  0.019 (57)  0.019 (59)  0.007 (60)  0.003 (62)  0.012 (63)  0.003 (64)  0.008 (66)  0.014
(67)  0.005 (76)  0.005 (77)  0.011 (78)  0.029 (79)  0.003 (80)  0.004
[36]  TOTAL   1.549
( 7)  0.147 ( 8) -0.171 (25)  0.177 (26)  0.642 (27)  0.044 (28)  0.064 (29)  0.014 (30)  0.119 (31)  0.059 (32)  0.075 (33)  0.004
(34)  0.004 (51)  0.007 (52)  0.001 (53)  0.002 (55)  0.014 (56)  0.021 (57)  0.024 (58)  0.005 (59)  0.002 (60)  0.014 (62)  0.027
(63)  0.002 (64)  0.011 (66)  0.063 (67)  0.033 (76)  0.010 (77)  0.006 (78)  0.007 (79)  0.096 (80)  0.023
[37]  TOTAL  34.176
( 2)  1.416 ( 3)  2.123 ( 7) 20.634 ( 8) -8.493 (25)  5.933 (26)  3.921 (27)  1.861 (28)  0.764 (29)  0.454 (30)  1.436 (31)  1.090
(32)  0.239 (33)  0.122 (34)  0.066 (47)  0.005 (48)  0.024 (49)  0.024 (50)  0.032 (51)  0.024 (52)  0.011 (53)  0.005 (54)  0.020
(55)  0.002 (56)  0.349 (57)  0.668 (58)  0.015 (59)  0.050 (60)  0.063 (61)  0.037 (62)  0.145 (63)  0.029 (64)  0.073 (65)  0.004
(66)  0.385 (67)  0.074 (76)  0.317 (77)  0.151 (78)  0.048 (79)  0.028 (80)  0.025
[38]  TOTAL   4.067
( 7)  0.044 ( 8) -0.170 (25)  0.206 (26)  2.449 (27)  0.067 (28)  0.208 (29)  0.011 (30)  0.252 (31)  0.543 (32)  0.172 (33)  0.004
(34)  0.020 (51)  0.149 (56)  0.009 (57)  0.017 (58)  0.002 (59)  0.001 (60)  0.001 (62)  0.009 (64)  0.009 (66)  0.019 (67)  0.010
(76)  0.021 (77)  0.001 (78)  0.010 (79)  0.001
[39]  TOTAL  14.478
( 7)  0.257 ( 8) -0.219 (25)  0.298 (26)  0.772 (27)  0.093 (28)  0.310 (29)  0.027 (30)  0.332 (31)  0.151 (32)  0.221 (33)  0.007
(34)  0.037 (48)  0.028 (49)  0.001 (50)  0.007 (51)  0.002 (54)  0.016 (55)  0.002 (56)  0.899 (57)  8.631 (58)  0.010 (59)  0.010
(60)  0.408 (61)  0.027 (62)  0.214 (63)  0.013 (64)  0.841 (65)  0.005 (66)  0.472 (67)  0.047 (76)  0.064 (77)  0.017 (78)  0.022
(79)  0.002 (80)  0.450
TOTALS  TOTAL 350.187
( 1)  0.070 ( 2) 10.417 ( 3)  5.710 ( 7) 49.493 ( 8)-60.657 (25) 19.755 (26) 46.989 (27) 11.051 (28) 23.645 (29)  2.320 (30)  9.791
(31)  7.806 (32) 16.049 (33)  2.804 (34)  0.539 (47)  0.468 (48)  4.097 (49)  0.942 (50)  2.538 (51)  8.190 (52)  2.284 (53)  2.366
(54)  1.534 (55)  0.319 (56) 33.754 (57) 66.632 (58)  4.424 (59)  3.504 (60)  6.436 (61)  5.500 (62)  6.242 (63)  2.079 (64)  7.766
(65)  2.910 (66) 19.610 (67)  4.501 (76) 12.482 (77)  2.636 (78)  2.186 (79)  0.393 (80)  0.612
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KEY: Entries are in thousands.

TABLE 5d
Displacement by [39 Sectors]/(80 Occupations) for Production Applications
Reference Path R and Scenario 000

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[ 1]  TOTAL   0.404
( 7)  0.036 ( 8) -0.027 (49)  0.001 (50)  0.002 (51)  0.088 (52)  0.004 (55)  0.011 (56)  0.011 (57)  0.095 (58)  0.004 (62)  0.002
(63)  0.002 (64)  0.003 (66)  0.064 (67)  0.005 (76)  0.099 (78)  0.003
[ 2]  TOTAL   0.753
( 7)  0.308 ( 8) -0.180 (48)  0.001 (50)  0.002 (51)  0.003 (52)  0.052 (53)  0.020 (56)  0.034 (57)  0.158 (58)  0.063 (60)  0.013
(61)  0.002 (62)  0.003 (63)  0.003 (65)  0.003 (66)  0.158 (67)  0.003 (76)  0.092 (77)  0.001 (78)  0.008 (79)  0.004
[ 3]  TOTAL   0.065
( 7)  0.070 ( 8) -0.175 (51)  0.096 (56)  0.007 (57)  0.015 (62)  0.002 (64)  0.002 (66)  0.004 (67)  0.022 (76)  0.014 (78)  0.003
(79)  0.001
[ 4]  TOTAL   1.745
( 7)  0.664 ( 8) -0.526 (47)  0.143 (48)  0.031 (49)  0.003 (50)  0.006 (56)  0.149 (57)  0.671 (58)  0.007 (59)  0.007 (60)  0.020
(61)  0.001 (62)  0.026 (65)  0.002 (66)  0.403 (67)  0.006 (76)  0.096 (78)  0.032
[ 5]  TOTAL   0.382
( 7)  1.417 ( 8) -2.029 (47)  0.004 (48)  0.002 (50)  0.102 (56)  0.062 (57)  0.422 (59)  0.006 (60)  0.004 (61)  0.001 (62)  0.016
(66)  0.200 (67)  0.002 (76)  0.050 (77)  0.001 (78)  0.117
[ 6]  TOTAL   0.693
( 7)  0.133 ( 8) -0.103 (47)  0.021 (48)  0.003 (49)  0.068 (50)  0.010 (51)  0.002 (56)  0.041 (57)  0.279 (59)  0.029 (62)  0.009
(66)  0.118 (67)  0.001 (76)  0.069 (78)  0.011
[ 7]  TOTAL   0.951
( 7)  0.475 ( 8) -0.241 (47)  0.008 (48)  0.003 (50)  0.019 (56)  0.071 (57)  0.382 (58)  0.002 (59)  0.010 (60)  0.006 (61)  0.002
(62)  0.004 (66)  0.114 (67)  0.007 (76)  0.054 (78)  0.030 (79)  0.001
[ 8]  TOTAL   6.946
( 7)  0.221 ( 8) -1.014 (48)  0.002 (49)  0.001 (50)  0.011 (51)  5.483 (52)  0.002 (53)  0.001 (55)  0.002 (56)  0.234 (57)  0.202
(58)  0.001 (60)  0.015 (61)  0.003 (62)  0.052 (63)  0.003 (64)  0.004 (66)  0.313 (67)  0.034 (76)  1.254 (77)  0.005 (78)  0.114
[ 9]  TOTAL   0.195
( 7)  0.037 ( 8) -0.108 (55)  0.133 (56)  0.064 (57)  0.012 (60)  0.001 (62)  0.003 (66)  0.023 (67)  0.002 (76)  0.022 (78)  0.004
[10]  TOTAL   5.747
( 7)  0.615 ( 8) -0.658 (47)  0.001 (48)  0.029 (49)  0.024 (50)  0.612 (51)  0.004 (52)  0.003 (54)  0.016 (55)  0.003 (56)  0.821
(57)  0.369 (58)  0.045 (59)  0.087 (60)  0.564 (61)  0.031 (62)  0.044 (63)  0.010 (64)  0.083 (65)  2.287 (66)  0.205 (67)  0.109
(76)  0.370 (77)  0.038 (78)  0.033
[11]  TOTAL   0.937
( 7)  0.010 ( 8) -0.074 (50)  0.003 (54)  0.003 (55)  0.064 (56)  0.036 (57)  0.004 (58)  0.009 (60)  0.003 (64)  0.798 (65)  0.014
(66)  0.012 (67)  0.009 (76)  0.039 (77)  0.002
[12]  TOTAL   2.129
( 7)  0.097 ( 8) -0.326 (48)  0.004 (49)  0.003 (50)  0.065 (53)  0.002 (54)  1.046 (55)  0.003 (56)  0.155 (57)  0.064 (58)  0.003
(59)  0.002 (60)  0.012 (61)  0.030 (62)  0.014 (63)  0.001 (64)  0.618 (65)  0.016 (66)  0.118 (67)  0.039 (76)  0.114 (77)  0.026
(78)  0.022
[13]  TOTAL   0.465
( 7)  0.003 ( 8) -0.018 (50)  0.002 (54)  0.179 (56)  0.008 (60)  0.001 (62)  0.001 (64)  0.228 (66)  0.022 (67)  0.001 (76)  0.032
(77)  0.001 (78)  0.003
[14]  TOTAL   3.323
( 7)  0.023 ( 8) -0.062 (50)  0.001 (54)  0.124 (55)  0.007 (56)  0.021 (57)  0.005 (58)  0.001 (60)  0.004 (64)  3.075 (65)  0.002
(66)  0.029 (67)  0.008 (76)  0.076 (77)  0.003 (78)  0.002
[15]  TOTAL   7.150
( 7)  0.182 ( 8) -0.269 (47)  0.001 (48)  0.004 (49)  0.005 (50)  0.004 (51)  0.001 (52)  1.982 (53)  0.071 (54)  0.002 (55)  0.001
(56)  0.216 (57)  0.419 (58)  2.317 (59)  0.050 (60)  0.500 (61)  0.009 (62)  0.028 (63)  0.582 (64)  0.017 (65)  0.002 (66)  0.293
(67)  0.049 (76)  0.630 (77)  0.002 (78)  0.049
[16]  TOTAL   3.812
( 7)  0.066 ( 8) -0.052 (48)  0.018 (49)  0.001 (50)  0.002 (52)  0.020 (54)  0.005 (56)  0.216 (57)  0.568 (58)  0.940 (59)  0.009
(60)  0.147 (61)  0.038 (62)  0.035 (63)  0.885 (64)  0.584 (65)  0.002 (66)  0.016 (67)  0.210 (76)  0.090 (77)  0.003 (78)  0.008
[17]  TOTAL   5.700
( 7)  0.533 ( 8) -1.120 (47)  0.002 (48)  0.013 (49)  0.007 (50)  0.054 (51)  0.004 (52)  0.075 (53)  2.205 (54)  0.005 (55)  0.003
(56)  0.596 (57)  0.881 (58)  0.080 (59)  0.029 (60)  0.138 (61)  0.010 (62)  0.084 (63)  0.006 (64)  0.011 (65)  0.030 (66)  0.535
(67)  0.705 (76)  0.476 (77)  0.159 (78)  0.176
[18]  TOTAL   1.701
( 7)  0.107 ( 8) -0.613 (48)  0.002 (50)  0.004 (53)  0.007 (54)  0.001 (56)  0.080 (57)  0.021 (58)  0.001 (60)  0.021 (61)  0.002
(62)  0.006 (63)  0.002 (64)  0.004 (65)  0.002 (66)  0.026 (67)  0.047 (76)  0.075 (77)  1.863 (78)  0.002 (80)  0.039
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[19]  TOTAL   10.782
( 7)  1.099 ( 8) -1.549 (47)  0.232 (48)  2.271 (49)  0.016 (50)  0.045 (52)  0.001 (53)  0.004 (54)  0.002 (55)  0.001 (56)  2.601
(57)  3.974 (58)  0.036 (59)  0.022 (60)  0.569 (61)  0.080 (62)  0.144 (63)  0.004 (65)  0.006 (66)  0.521 (67)  0.045 (76)  0.576
(77)  0.006 (78)  0.076
[20]  TOTAL   29.096
( 7)  1.500 ( 8) -0.761 (47)  0.012 (48)  0.749 (49)  0.020 (50)  0.017 (51)  0.011 (52)  0.003 (53)  0.002 (54)  0.006 (55)  0.002
(56) 10.189 (57) 14.342 (58)  0.065 (59)  0.153 (60)  1.176 (61)  0.510 (62)  0.105 (63)  0.032 (64)  0.013 (65)  0.020 (66)  0.365
(67)  0.166 (76)  0.346 (77)  0.024 (78)  0.033
[21]  TOTAL   11.153
( 7)  1.817 ( 8) -3.307 (47)  0.004 (48)  0.166 (49)  0.002 (50)  0.009 (51)  0.009 (53)  0.002 (54)  0.003 (55)  0.002 (56)  4.858
(57)  5.456 (58)  0.032 (59)  0.025 (60)  0.414 (61)  0.665 (62)  0.325 (63)  0.009 (64)  0.007 (65)  0.010 (66)  0.323 (67)  0.134
(76)  0.159 (77)  0.011 (78)  0.018
[22]  TOTAL   22.415
( 7)  1.747 ( 8) -2.506 (47)  0.002 (48)  0.220 (49)  0.010 (50)  0.023 (51)  0.005 (52)  0.002 (54)  0.002 (55)  0.002 (56)  5.866
(57) 10.025 (58)  0.078 (59)  0.076 (60)  0.999 (61)  3.303 (62)  0.247 (63)  0.039 (64)  0.065 (65)  0.055 (66)  0.829 (67)  0.860
(76)  0.418 (77)  0.011 (78)  0.037
[23]  TOTAL    8.505
( 7)  2.346 ( 8) -0.066 (47)  0.001 (48)  0.160 (49)  0.008 (50)  0.013 (52)  0.001 (54)  0.006 (56)  1.252 (57)  1.949 (58)  0.020
(59)  0.023 (60)  0.214 (61)  0.074 (62)  2.100 (63)  0.015 (64)  0.005 (65)  0.010 (66)  0.080 (67)  0.091 (76)  0.156 (77)  0.015
(78)  0.021 (79)  0.007 (80)  0.004
[24]  TOTAL    3.258
( 7)  0.309 ( 8) -0.297 (47)  0.012 (48)  0.018 (49)  0.601 (50)  0.033 (51)  0.001 (52)  0.002 (53)  0.003 (54)  0.005 (56)  0.200
(57)  0.417 (58)  0.009 (59)  1.316 (60)  0.115 (61)  0.013 (62)  0.020 (63)  0.007 (64)  0.001 (65)  0.011 (66)  0.136 (67)  0.038
(76)  0.259 (77)  0.004 (78)  0.024
[25]  TOTAL    0.461
( 7)  0.449 ( 8) -0.822 (48)  0.002 (49)  0.002 (50)  0.285 (56)  0.076 (57)  0.275 (59)  0.002 (62)  0.012 (63)  0.001 (66)  0.064
(67)  0.003 (76)  0.044 (78)  0.062
[26]  TOTAL    1.557
( 7)  0.495 ( 8) -1.275 (47)  0.004 (48)  0.019 (49)  0.003 (50)  0.983 (51)  0.005 (52)  0.001 (53)  0.004 (54)  0.006 (55)  0.014
(56)  0.252 (57)  0.315 (59)  0.009 (60)  0.028 (61)  0.019 (62)  0.026 (63)  0.002 (64)  0.002 (65)  0.037 (66)  0.158 (67)  0.031
(76)  0.331 (77)  0.011 (78)  0.076
[27]  TOTAL    3.873
( 7)  0.453 ( 8) -0.545 (47)  0.001 (48)  0.049 (49)  0.013 (50)  0.041 (51)  0.003 (52)  0.006 (53)  0.008 (54)  0.017 (55)  0.028
(56)  0.607 (57)  0.591 (58)  0.149 (59)  0.580 (60)  0.372 (61)  0.134 (62)  0.126 (63)  0.044 (64)  0.136 (65)  0.085 (66)  0.073
(67)  0.679 (76)  0.135 (77)  0.048 (78)  0.011 (79)  0.011 (80)  0.016
[28]  TOTAL   18.309
( 7)  5.148 ( 8) -0.688 (47)  0.006 (48)  0.128 (49)  0.075 (50)  0.012 (51)  0.007 (52)  0.015 (53)  0.002 (54)  0.004 (55)  0.002
(56)  0.649 (57) 10.007 (58)  0.143 (59)  0.345 (60)  0.085 (61)  0.103 (62)  0.514 (63)  0.172 (64)  0.015 (65)  0.009 (66)  0.859
(67)  0.051 (76)  0.530 (77)  0.003 (78)  0.112 (79)  0.002
[29]  TOTAL    5.138
( 7)  1.602 ( 8) -3.889 (47)  0.001 (48)  0.022 (49)  0.005 (50)  0.007 (51)  0.030 (52)  0.003 (53)  0.002 (54)  0.001 (55)  0.001
(56)  1.161 (57)  1.680 (58)  0.015 (59)  0.004 (60)  0.044 (61)  0.054 (62)  0.197 (63)  0.005 (64)  0.017 (65)  0.013 (66)  2.092
(67)  0.075 (76)  1.837 (77)  0.014 (78)  0.111 (79)  0.030 (80)  0.002
[30]  TOTAL   -1.910
( 7)  0.902 ( 8) -3.434 (48)  0.001 (56)  0.031 (57)  0.034 (60)  0.003 (62)  0.206 (64)  0.001 (66)  0.059 (67)  0.002 (76)  0.063
(77)  0.008 (78)  0.015 (79)  0.190 (80)  0.006
[31]  TOTAL    2.736
( 7)  3.312 ( 8) -2.840 (48)  0.005 (50)  0.025 (51)  0.001 (56)  0.104 (57)  0.679 (58)  0.008 (59)  0.002 (60)  0.011 (61)  0.005
(62)  0.136 (66)  0.280 (67)  0.010 (76)  0.270 (77)  0.008 (78)  0.713 (79)  0.002
[32]  TOTAL    6.230
( 7)  1.227 ( 8) -4.303 (47)  0.006 (48)  0.089 (49)  0.021 (50)  0.081 (51)  0.405 (52)  0.089 (53)  0.022 (54)  0.034 (55)  0.009
(56)  1.344 (57)  2.136 (58)  0.325 (59)  0.231 (60)  0.204 (61)  0.171 (62)  0.357 (63)  0.063 (64)  0.189 (65)  0.139 (66)  1.744
(67)  0.133 (76)  1.391 (77)  0.059 (78)  0.051 (79)  0.003 (80)  0.008
[33]  TOTAL   13.058
( 7)  0.456 ( 8) -4.536 (48)  0.023 (49)  0.023 (50)  0.015 (51)  1.828 (52)  0.004 (53)  0.001 (54)  0.023 (55)  0.006 (56)  0.385
(57)  0.736 (58)  0.029 (59)  0.415 (60)  0.247 (61)  0.161 (62)  0.952 (63)  0.140 (64)  0.918 (65)  0.141 (66)  8.372 (67)  0.726
(76)  1.864 (77)  0.062 (78)  0.038 (79)  0.002 (80)  0.025
[34]  TOTAL  -11.189
( 7)  0.440 ( 8)-12.135 (48)  0.007 (49)  0.002 (50)  0.005 (51)  0.007 (52)  0.001 (54)  0.004 (55)  0.004 (56)  0.057 (57)  0.089
(58)  0.005 (59)  0.002 (60)  0.017 (61)  0.009 (62)  0.038 (63)  0.002 (64)  0.024 (65)  0.001 (66)  0.049 (67)  0.027 (76)  0.032
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 (77)  0.058 (78)  0.055 (79)  0.004 (80)  0.003
[35]   TOTAL  -0.788
 ( 7)  0.113 ( 8) -1.057 (50)  0.005 (51)  0.006 (56)  0.019 (57)  0.019 (59)  0.007 (60)  0.003 (62)  0.012 (63)  0.003 (64)  0.008
 (66)  0.014 (67)  0.005 (76)  0.005 (77)  0.011 (78)  0.029 (79)  0.003 (80)  0.004
[36]   TOTAL   0.347
 ( 7)  0.147 ( 8) -0.171 (51)  0.007 (52)  0.001 (53)  0.002 (55)  0.014 (56)  0.021 (57)  0.024 (58)  0.005 (59)  0.002 (60)  0.014
 (62)  0.027 (63)  0.002 (64)  0.011 (66)  0.063 (67)  0.033 (76)  0.010 (77)  0.006 (78)  0.007 (79)  0.096 (80)  0.023
[37]   TOTAL  14.750
 ( 7) 20.634 ( 8) -8.493 (47)  0.005 (48)  0.024 (49)  0.024 (50)  0.032 (51)  0.024 (52)  0.011 (53)  0.005 (54)  0.020 (55)  0.002
 (56)  0.349 (57)  0.668 (58)  0.015 (59)  0.050 (60)  0.063 (61)  0.037 (62)  0.145 (63)  0.029 (64)  0.073 (65)  0.004 (66)  0.385
 (67)  0.074 (76)  0.317 (77)  0.151 (78)  0.048 (79)  0.028 (80)  0.025
[38]   TOTAL   0.135
 ( 7)  0.044 ( 8) -0.170 (51)  0.149 (56)  0.009 (57)  0.017 (58)  0.002 (59)  0.001 (60)  0.001 (62)  0.009 (64)  0.009 (66)  0.019
 (67)  0.010 (76)  0.021 (77)  0.001 (78)  0.010 (79)  0.001
[39]   TOTAL  12.229
 ( 7)  0.257 ( 8) -0.219 (48)  0.028 (49)  0.001 (50)  0.007 (51)  0.002 (54)  0.016 (55)  0.002 (56)  0.899 (57)  8.631 (58)  0.010
 (59)  0.010 (60)  0.408 (61)  0.027 (62)  0.214 (63)  0.013 (64)  0.841 (65)  0.005 (66)  0.472 (67)  0.047 (76)  0.064 (77)  0.017
 (78)  0.022 (79)  0.002 (80)  0.450
TOTALS  TOTAL 193.243
 ( 7) 49.493 ( 8)-60.657 (47)  0.468 (48)  4.097 (49)  0.942 (50)  2.538 (51)  8.190 (52)  2.284 (53)  2.366 (54)  1.534 (55)  0.319
 (56) 33.754 (57) 66.632 (58)  4.424 (59)  3.504 (60)  6.436 (61)  5.500 (62)  6.242 (63)  2.079 (64)  7.766 (65)  2.910 (66) 19.610
 (67)  4.501 (76) 12.482 (77)  2.636 (78)  2.186 (79)  0.393 (80)  0.612
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KEY: Entries are in thousands.

TABLE 8d
Displacement by (39 Sectors)/(80 Occupations) for Office Applications
Reference Path R and Scenario 000

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[ 1]  TOTAL   0.688
 ( 2)  0.023 ( 3)  0.011 (25)  0.066 (26)  0.379 (27)  0.009 (28)  0.047 (29)  0.001 (30)  0.064 (31)  0.023 (32)  0.040 (34)  0.003
[ 2]  TOTAL   0.240
 ( 2)  0.021 ( 3)  0.014 (25)  0.037 (26)  0.084 (27)  0.023 (28)  0.031 (29)  0.004 (30)  0.006 (31)  0.015 (32)  0.002
[ 3]  TOTAL   0.099
 ( 2)  0.011 ( 3)  0.010 (25)  0.018 (26)  0.027 (27)  0.006 (28)  0.011 (29)  0.002 (30)  0.004 (31)  0.007 (32)  0.003
[ 4]  TOTAL   0.364
 ( 2)  0.028 ( 3)  0.023 (25)  0.065 (26)  0.068 (27)  0.047 (28)  0.098 (29)  0.007 (30)  0.011 (31)  0.015 (32)  0.001
[ 5]  TOTAL   0.989
 ( 2)  0.111 ( 3)  0.096 (25)  0.178 (26)  0.205 (27)  0.194 (28)  0.084 (29)  0.032 (30)  0.036 (31)  0.047 (32)  0.004
[ 6]  TOTAL   0.153
 ( 2)  0.018 ( 3)  0.007 (25)  0.021 (26)  0.035 (27)  0.016 (28)  0.038 (29)  0.003 (30)  0.004 (31)  0.008 (32)  0.002
[ 7]  TOTAL   0.377
 ( 2)  0.067 ( 3)  0.021 (25)  0.079 (26)  0.107 (27)  0.026 (28)  0.040 (29)  0.006 (30)  0.012 (31)  0.013 (32)  0.007
[ 8]  TOTAL   2.894
 ( 2)  0.262 ( 3)  0.089 (25)  0.244 (26)  0.563 (27)  0.206 (28)  1.021 (29)  0.011 (30)  0.082 (31)  0.082 (32)  0.226 (33)  0.001
 (34)  0.107
[ 9]  TOTAL   0.093
 ( 2)  0.012 ( 3)  0.004 (25)  0.014 (26)  0.009 (27)  0.012 (28)  0.025 (29)  0.003 (30)  0.005 (31)  0.002 (32)  0.007
[10]  TOTAL   1.333
 ( 2)  0.182 ( 3)  0.054 (25)  0.140 (26)  0.184 (27)  0.110 (28)  0.519 (29)  0.003 (30)  0.037 (31)  0.043 (32)  0.059
[11]  TOTAL   0.191
 ( 2)  0.016 ( 3)  0.004 (25)  0.016 (26)  0.033 (27)  0.014 (28)  0.087 (30)  0.005 (31)  0.007 (32)  0.007
[12]  TOTAL   0.551
 ( 2)  0.045 ( 3)  0.013 (25)  0.062 (26)  0.098 (27)  0.038 (28)  0.233 (29)  0.004 (30)  0.021 (31)  0.018 (32)  0.019
[13]  TOTAL   0.120
 ( 2)  0.006 ( 3)  0.001 (25)  0.010 (26)  0.017 (27)  0.007 (28)  0.066 (30)  0.005 (31)  0.004 (32)  0.003
[14]  TOTAL   0.689
 ( 2)  0.055 ( 3)  0.013 (25)  0.052 (26)  0.132 (27)  0.038 (28)  0.311 (29)  0.008 (30)  0.024 (31)  0.021 (32)  0.034
[15]  TOTAL   0.758
 ( 2)  0.102 ( 3)  0.029 (25)  0.085 (26)  0.179 (27)  0.052 (28)  0.228 (29)  0.005 (30)  0.020 (31)  0.024 (32)  0.032
[16]  TOTAL   0.517
 ( 2)  0.059 ( 3)  0.016 (25)  0.059 (26)  0.109 (27)  0.027 (28)  0.177 (29)  0.005 (30)  0.018 (31)  0.021 (32)  0.026
[17]  TOTAL   1.304
 ( 2)  0.125 ( 3)  0.062 (25)  0.173 (26)  0.213 (27)  0.139 (28)  0.439 (29)  0.017 (30)  0.048 (31)  0.047 (32)  0.041
[18]  TOTAL   1.813
 ( 2)  0.163 ( 3)  0.039 (25)  0.248 (26)  0.339 (27)  0.221 (28)  0.319 (29)  0.055 (30)  0.184 (31)  0.126 (32)  0.078 (33)  0.039
 (34)  0.002
[19]  TOTAL   1.210
 ( 2)  0.104 ( 3)  0.056 (25)  0.152 (26)  0.174 (27)  0.118 (28)  0.477 (29)  0.021 (30)  0.036 (31)  0.051 (32)  0.021
[20]  TOTAL   2.017
 ( 2)  0.243 ( 3)  0.084 (25)  0.215 (26)  0.405 (27)  0.130 (28)  0.709 (29)  0.016 (30)  0.069 (31)  0.064 (32)  0.082
[21]  TOTAL   1.854
 ( 2)  0.199 ( 3)  0.083 (25)  0.220 (26)  0.271 (27)  0.219 (28)  0.646 (29)  0.016 (30)  0.054 (31)  0.064 (32)  0.080
[22]  TOTAL   2.362
 ( 2)  0.182 ( 3)  0.105 (25)  0.218 (26)  0.297 (27)  0.278 (28)  1.073 (29)  0.028 (30)  0.052 (31)  0.085 (32)  0.045
[23]  TOTAL   1.561
 ( 2)  0.151 ( 3)  0.067 (25)  0.187 (26)  0.211 (27)  0.185 (28)  0.582 (29)  0.015 (30)  0.058 (31)  0.056 (32)  0.046
[24]  TOTAL   0.606
 ( 2)  0.083 ( 3)  0.025 (25)  0.068 (26)  0.123 (27)  0.047 (28)  0.185 (29)  0.003 (30)  0.018 (31)  0.024 (32)  0.030
[25]  TOTAL   0.437
 ( 2)  0.056 ( 3)  0.032 (25)  0.057 (26)  0.079 (27)  0.082 (28)  0.074 (29)  0.009 (30)  0.014 (31)  0.025 (32)  0.009
[26]  TOTAL   1.504
 ( 2)  0.172 ( 3)  0.064 (25)  0.220 (26)  0.210 (27)  0.165 (28)  0.460 (29)  0.014 (30)  0.059 (31)  0.047 (32)  0.092
[27]  TOTAL   1.128
 ( 2)  0.115 ( 3)  0.030 (25)  0.138 (26)  0.199 (27)  0.101 (28)  0.359 (29)  0.011 (30)  0.064 (31)  0.050 (32)  0.059 (33)  0.002
[28]  TOTAL   5.370
 ( 2)  0.942 ( 3)  0.296 (25)  1.002 (26)  1.893 (27)  0.174 (28)  0.400 (29)  0.038 (30)  0.231 (31)  0.242 (32)  0.145 (33)  0.006
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(34)  0.001
[29]  TOTAL   6.127
( 2)  0.549 ( 3)  0.190 (25)  0.646 (26)  1.339 (27)  0.552 (28)  1.240 (29)  0.102 (30)  0.268 (31)  1.142 (32)  0.053 (33)  0.038
(34)  0.008
[30]  TOTAL   5.297
( 1)  0.070 ( 2)  0.147 ( 3)  0.057 (25)  0.311 (26)  0.406 (27)  0.291 (28)  0.226 (29)  0.068 (30)  3.390 (31)  0.293 (32)  0.020
(33)  0.017
[31]  TOTAL   1.793
( 2)  0.143 ( 3)  0.089 (25)  0.264 (26)  0.382 (27)  0.302 (28)  0.227 (29)  0.042 (30)  0.084 (31)  0.241 (32)  0.016 (33)  0.002
[32]  TOTAL  14.931
( 2)  1.152 ( 3)  0.284 (25)  1.453 (26)  3.062 (27)  1.113 (28)  4.190 (29)  0.152 (30)  0.560 (31)  0.575 (32)  2.273 (33)  0.011
(34)  0.105
[33]  TOTAL  40.098
( 2)  1.220 ( 3)  0.298 (25)  1.312 (26) 14.734 (27)  1.055 (28)  7.284 (29)  0.178 (30)  0.983 (31)  1.133 (32) 11.713 (33)  0.013
(34)  0.174
[34]  TOTAL  29.134
( 2)  2.094 ( 3)  1.288 (25)  4.559 (26) 12.486 (27)  2.899 (28)  0.297 (29)  0.709 (30)  0.919 (31)  1.286 (32)  0.064 (33)  2.531
(34)  0.002
[35]  TOTAL   1.532
( 2)  0.142 ( 3)  0.032 (25)  0.529 (26)  0.151 (27)  0.089 (28)  0.095 (29)  0.223 (30)  0.205 (31)  0.063 (32)  0.003
[36]  TOTAL   1.202
(25)  0.177 (26)  0.642 (27)  0.044 (28)  0.064 (29)  0.014 (30)  0.119 (31)  0.059 (32)  0.075 (33)  0.004 (34)  0.004
[37]  TOTAL  19.426
( 2)  1.416 ( 3)  2.123 (25)  5.933 (26)  3.921 (27)  1.861 (28)  0.764 (29)  0.454 (30)  1.436 (31)  1.090 (32)  0.239 (33)  0.122
(34)  0.066
[38]  TOTAL   3.932
(25)  0.206 (26)  2.449 (27)  0.067 (28)  0.208 (29)  0.011 (30)  0.252 (31)  0.543 (32)  0.172 (33)  0.004 (34)  0.020
[39]  TOTAL   2.248
(25)  0.298 (26)  0.772 (27)  0.093 (28)  0.310 (29)  0.027 (30)  0.332 (31)  0.151 (32)  0.221 (33)  0.007 (34)  0.037
TOTALS  TOTAL 156.944
( 1)  0.070 ( 2) 10.417 ( 3)  5.710 (25) 19.755 (26) 46.989 (27) 11.051 (28) 23.645 (29)  2.320 (30)  9.791 (31)  7.806 (32) 16.049
(33)  2.804 (34)  0.539
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KEY: Entries are in thousands.