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Economy-wide effects of a major increase in the wholesale price of electricity: New Results from the JOANNA Model

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Summary

- The *Hydro New Zealand* report (Bertram, Dempster, Gale and Terry 1992, Chapter 10) argued that a large increase in the price of electricity would do significant damage to New Zealand's macroeconomic performance by

  (i) squeezing the profitability, and hence the competitiveness, of traded-goods producers; and

  (ii) reducing disposable incomes, and thus the size of the domestic market (given that a higher price charged by a state-owned enterprise is a form of tax increase).

- Results from a 1985 BERL study, using the JOANNA computer model of the New Zealand economy, were cited in support. The 1985 study modelled the impact of a 25% increase in the electricity price and found a 1.1% shrinkage of GDP relative to 'business-as-usual', with real exports falling 2.3% and employment falling 1.7%. Despite higher returns to Government from ECNZ, total Government revenue actually fell 0.3% while expenditure rose 0.4%, mainly due to increased unemployment benefit payments. The model thus suggested that raising the electricity price in the hope of reducing the budget deficit would be counter-productive.

- An updated version of the JOANNA model has now been used to replicate the 1985 work, and to explore separately the two issues of price competitiveness and disposable-income effects. This paper describes the results of the new work.

- A simple replication of the 1985 simulation, using the new database, closely matches the 1985 results for GDP, employment, prices, the balance of payments, sectoral output and major export commodities. The adverse effect on the pulp and paper sector's exports is somewhat less severe, and that on the basic metals sector somewhat more severe, than in the 1985 run.

- The only significant change in the new version of the model is the effect on government revenue, which now ends up higher (rather than lower) than business-as-usual, following the electricity price shock. As a result, in the 1992 replication of the 1985 study the 25% electricity price increase succeeds in strengthening the Government's fiscal balance by a net $15 million, at the cost of a 1% fall in GDP, a 1.8% fall in employment, and a $126 million worsening of the balance of payments current account. This still looks a costly and inefficient way for Government to reduce its budget deficit, but the result is less dramatic than the 1985 finding that a higher electricity price would actually worsen the model's budget deficit.

- The explanation for this change in the result for the Government budget balance is the increased importance of GST revenue and SOE profits in total government revenue, and the reduced share of direct income tax. The restructuring of the New Zealand tax system since 1984, it appears, has had the effect of making the government budget less sensitive to changes in GDP such as that triggered in the model economy by an electricity price rise.

- Two supplementary replications of the earlier study were carried out with alternative 'closure rules' for the model.

  - The first of these held the money wage rate fixed, thus allowing the real wage to fall as the economy's price level rose. The resulting combination of an electricity price increase with a wage freeze produced a strengthening of both the balance of payments and the Government budget, and a less severe fall in GDP and employment

than in the initial replication, with the cost squeeze on export competitiveness greatly reduced and some export sectors actually gaining extra volume (that is, for these sectors the competitiveness gain from the falling real wage outweighed the cost pressure from the electricity price rise).

- The second supplementary experiment allowed the nominal exchange rate as well as the money wage rate to vary, so as to leave the balance of payments current account unchanged. The results closely matched those of the previous experiment.

- These two exercises illustrate the point that a long-run return to a 'normal' real exchange rate for the economy following an electricity price shock would leave significant distributional effects, with real wages falling to compensate for the higher cost of electricity as an input to traded goods production.

- Three new experiments were then conducted which 'recycled' the additional government revenues from ECNZ back to the private sector, thus reducing or eliminating the direct effect of the price shock on government revenue. The conclusion from this work is that the model results are extremely sensitive to the choice of recycling mechanism. Passing the proceeds from an electricity price increase to households raises consumption spending, which leads to a significantly increased squeeze on the competitiveness of the economy, and hence on the fortunes of traded-goods producers at a given nominal exchange rate, compared to the impact of the same price increase without revenue recycling. In contrast, if additional electricity sales revenues are used to reduce the rate of GST, the negative economy-wide effect of the price increase is greatly reduced. Although pulp and paper, and basic metals, remain clear 'losers' under this last scenario, some other sectors see their export performance improve, and the Government budget balance emerges almost as strong as in the case where all additional revenue is retained rather than recycled.

The 1985 BERL Study

In 1985 the Business Round Table and Comalco commissioned a BERL study of the economy-wide effects of energy price increases. The study used the JOANNA computer model of the New Zealand economy, developed by the Project on Economic Planning at Victoria University, to explore the effects of such price increases on export performance, output, employment, and the government's fiscal deficit (Frater et al 1985a, 1985b).

The impetus for the study was the large price increases applied by the New Zealand Electricity Division (now Electricity Corporation of New Zealand, ECNZ) and State Coal Mines from 1 April 1985, and the prospect that these would be followed by further increases in electricity and coal prices (Frater et al 1985a p.1). The price increases reflected the Treasury's view that state-owned enterprises should set their prices so as to achieve a full commercial return on capital, and that the pre-1985 prices of coal and electricity had represented "an effective subsidy (amounting to several hundred million dollars per annum) to consumers" (NZ Treasury 1984 pp.302-303).

A prime motivation for the price increases was clearly to raise additional net revenue - that is, to strengthen the Government's budget balance, which was at that time in substantial deficit. The intention behind the price increases was not, therefore, to raise revenue from energy purchasers to be 'recycled' directly back into the disposable incomes of taxpayers (for example, by income-tax reductions designed to match the increase in energy-SOE profits). Rather the intention was to

transfer purchasing power from the private sector to the Government, which would use the funds to reduce its borrowing requirement.

The energy price increases, in other words, were intended to produce both relative-price changes and higher tax revenues. The 1985 study modelled them accordingly. Two sets of economy-wide effects were thereby combined: the allocative effects of a 25% rise in the price of electricity relative to the prices of other industrial inputs (including other forms of energy); and the income effect of a tax increase, represented by the increase in government revenue from increased NZED profits.

The results of the 1985 JOANNA run #10L appear in the first column of data in Table 1. The 'L' in the identification number indicates that the long-run version of JOANNA was used, in which the expected rates of return on capital are equalised across sectors, and a fixed total stock of sectorally-mobile capital is allocated among sectors in such a way as to yield these rates of return. (The level of aggregate real investment expenditure including housing and Government social investment was held fixed at no change, as was Government consumption expenditure except insofar as wage rates affected the cost of Government services.) The model was expanded to 26 sectors by disaggregating electricity (NZSIC group 4101) from the electricity, gas and water sector (NZSIC 14); by splitting mining and quarrying (SNA 4) into coal mining (NZSIC 2100), oil and natural gas (NZSIC 2201 and 2202) and mining and quarrying nec; and by splitting paper and printing into two - pulp, paper and paperboard (NZSIC 3411) and the rest. (See Frater et al 1985b p.10).

The model runs indicated that (insofar as the JOANNA model accurately reproduced the behaviour of the New Zealand economy) a 25% increase in electricity price would lead to a 1.1% reduction in GDP and a $46 million worsening of the balance of payments current account in 1981/82 dollars. The increase in electricity price was predicted actually to worsen the Government's budget deficit by $87 million because of erosion of the tax base and higher unemployment benefit payments.

There were clearly a number of separate mechanisms at work in the model to produce these results. The most important of these were:

- Higher electricity prices drive up the price of consumer goods. In Run #10L, a 25% rise in electricity price drove up the price of consumer goods (pTOT1) by 1.1% and the economy-wide GDP deflator (pGDP) by 1.2% (Table 1). These higher prices for consumer goods represent a reduction in the disposable income of consumers as a group, who then reduce their expenditure on other goods and services. This causes a fall in domestic aggregate demand, and hence a multiplier contraction of output and employment across all sectors which sell into the local market. This contraction in turn feeds through to reduced demand for imports (strengthening the balance of payments current account) and a reduction in Government's revenue from income tax. As economy-wide employment falls, Government spending on unemployment benefits increases; this combines with the lower tax take to put downward pressure on the Government budget

balance.

- Higher electricity prices raise the costs of industry by amounts which vary depending upon the share of each sector's costs accounted for by electricity. (The elasticity of substitution of other inputs for electricity is zero in the JOANNA model, which uses fixed sectoral input-output coefficients to determine the demand for all non-factor inputs). Higher input costs put upward pressure on the prices charged by each industry, and insofar as industrial products are internationally traded, these price increases drive some buyers away from New Zealand-produced goods towards overseas-produced substitutes for them. Sales volume falls as a result, and output is reduced by amounts determined by the price elasticity of demand for New Zealand products in world markets. Reductions in GDP result, which lower the economy-wide demand for the (fixed) capital stock, thus drive down the rental cost of capital, and thus enable some part of the increased cost of electricity as an input to be absorbed in lower capital costs. In the final equilibrium, thus, the increased electricity price is partly passed on to final product prices, and partly absorbed as a reduced economy-wide rate of return on capital. Run #10L held the nominal exchange rate fixed, which prevents a fall in the value of the New Zealand dollar from mitigating the cost pressures on competitiveness.

  The overall effect of the cost squeeze on traded-goods producers is therefore to reduce their sales, and hence market share, both in export markets (as overseas buyers reduce their orders) and in local markets (as import penetration increases).

- Falling sales volume for local traded-goods producers, due to their loss of competitiveness, leads to falling output and less employment. The resulting fall in payments by traded goods producers to local suppliers of material inputs and labour then results in a second downward multiplier effect on the economy, reducing GDP and the tax base, but again reducing import demand and so strengthening the balance of payments current account.

The above description of the economy-wide changes traced by Run #10L indicates uniform downward pressure on output, employment, and profitability, due to the fall in revenue from exports and import-substituting sales by industry, and the drop in employment as industrial output is cut back. The negative effect on aggregate exports (xTOT5) is unequivocal.

Offsetting forces are at work, however, with respect to imports and the Government budget. Imports are increased by the falling competitiveness of local industry, but reduced as New Zealand's aggregate demand falls due to falling income. Overall, in Run #10L the model indicates that imports fall - that is, the fall in aggregate demand outweighs the loss of competitiveness. (This, obviously, is no comfort to local import-competing manufacturers who face falling shares in a shrinking market.)

The Government budget is strengthened by increased revenues from electricity sector profits, but weakened by falling income tax revenues and higher benefit payments. Overall, Run #10L resulted in a net weakening.

There are three fixed points around which these adjustments took place in Run #10L: a fixed nominal exchange rate, fixed government real consumption spending, and a fixed real wage. (Exogenous variables are marked with an asterisk in Table 1). (The fixed real wage explains the rise in the nominal wage rate, pLAB, in Table 1 despite falling employment - the increased money wage results from the model acting to prevent the real wage from falling as a result of the increase in the Consumer Price Index induced by the electricity price rise.)

In summary, the 1985 BERL study provided numerical estimates for a set of impacts which were intuitively apparent to many industrial observers of the 1985 price increase, namely that (other things equal) raising the price of a major input such as electricity tended to squeeze the profitability of traded-goods production, throw the economy into a traded-goods-led recession, and thereby produce an economy-wide fall in profitability, output and employment.

The most severe single impact identified was the 7% volume fall in pulp and paper exports (xXPT9). The other economy-wide overall effects mostly came out to a couple of percentage points or less. Because the model used fixed input-output coefficients and allowed no discretionary adjustments to real wages, to the nominal exchange rate or to the Government's fiscal stance, it probably produced a somewhat overstated picture of the output repercussions of an electricity price increase, since the higher real exchange rate caused by the electricity price rise and the subsequent rise in the New Zealand price level were not offset by any countervailing adjustments. Clearly a fall in the real wage, a fall in the nominal exchange rate (equivalent to a loosening of monetary policy under the present floating-rate regime), or a fiscal expansion by Government to re-inject the additional revenues, could have regained some of the ground lost in the computer simulation so far as the economy as a whole is concerned.

Such offsetting adjustments would have left lasting effects on the distribution of income and wealth within the economy. Changes to the economy-wide real wage and/or nominal exchange rate which sufficed to restore GDP and/or the balance of payments to their initial position, would still have left electricity-intensive sectors such as pulp and paper and basic metals at a disadvantage relative to their initial state. A fall in the real wage obviously would involve a redistribution from labour to the recipients of the profits from electricity sales, while a fall in the nominal exchange rate would put some redistributive pressure on import-intensive non-traded-goods producers.

Four Limitations of the Model

The JOANNA model is of course just that - a model, not the actual New Zealand economy in its full complexity. Four limitations of the model need to be borne in mind in interpreting the 1985 experiments with an electricity price rise. The first, already referred to above, is that the model has

a production function which allows producers to substitute capital for labour and vice versa, but does not provide for substitution of capital and/or labour for energy and other material inputs to production, which are determined by the coefficients of the input-output matrix in the model's database. This means that the model's only way to reduce electricity use in the economy is by reducing production in sectors which use electricity as an input. Clearly there is a possibility that this approach may miss some paths of flexible adjustment in the actual New Zealand economy, and it would be useful to repeat the experiments with a more flexible production function inserted in the model. Such an extension to the JOANNA model is planned as part of future research.

A second limitation is the model's lack of a monetary sector. Insofar as a tax increase succeeds in strengthening the government's budget balance and thus reducing its borrowing requirement, and insofar as such reduced borrowing by the government translates into lower interest rates and easier finance for private sector agents wishing to undertake deficit spending of their own, and hence to a countervailing increase in private-sector expenditure, it could be argued that a complete description of economy-wide effects should include some relationship between the budget balance and monetary conditions. Because the JOANNA model does not have a monetary sector, these possible second-round effects of changes in the government budget balance could not be included explicitly in the experiments discussed in this paper. The model economy was simply exposed to a straightforward fiscal contraction, with no offsetting exchange-rate adjustment, tax cuts or monetary relaxation. In later sections of this paper some experiments are done which include endogenous exchange-rate adjustment and ad-hoc tax cuts. But so far as monetary effects go, all that can be done at the present stage of work is to note whether the government budget balance is strengthened or weakened, and to bear in mind that the monetary implications of such changes in the budget out-turn will depend on the monetary-policy rules which are assumed to be applied by government to the financing of any deficit or surplus. (Thus for instance, if any change in the government deficit is assumed to result in a change in the money supply, then a weakening of the budget balance would imply some downward pressure on interest rates, with possible expansionary feedback effects on private-sector spending; whereas if changes in the deficit are assumed to be fully-funded by adjustments to bond sales, the monetary feedbacks would go the other way.)

In the international literature on modelling carbon taxes it is now common to use the device of 'revenue recycling' (reinjecting all additional revenues back into the private sector) to eliminate any direct effect on total government revenue from taxes or levies on the price of energy, thus avoiding (or at least, reducing) the need to consider monetary feedbacks. Three preliminary experiments with revenue recycling have been carried out for this paper using the updated version of the model (see below).

The third limitation is that the model is neoclassical and assumes the possibility of continuous, flexible adjustment by all sectors of the economy. In the cases of sectors such as pulp and paper and basic metals, an important characteristic of these industries as they actually exist in New Zealand is the very small number of very large firms, operating large-scale plant. The proportional

adjustments of output and export volume shown for these sectors in Table 1 are thus notional changes. In practice, these sectors are likely to adjust to major price shocks by large discrete changes in output volume (for example, the closing-down of a paper machine, furnace or potline) rather than by the fine-tuned smooth changes shown by the model.

The fourth limitation is that the input-output database ties the model to the structure of the economy in a particular past year. The 1985 study used a version of the JOANNA model based on the 1981/82 input-output table for the New Zealand economy. It is possible that structural changes over the decade have been sufficiently great to render the old version of the model a poor guide to the likely performance of the economy in the 1990s. An input-output table is now available for 1986/87, and the JOANNA model has recently been updated to use this information. The model has also been updated by using fiscal-year 1991 data for the composition of Government revenue and expenditure. Bertram et al (1992 p. 115) foreshadowed the possibility of repeating the 1985 study using the updated model, and such an exercise is described in the next section.

New Results with the Updated Model.

Six experiments have been carried out using the updated version of the JOANNA model. The results of these are set out in Columns [2] to [7] of Table 1 alongside the results from the original 1985 study in Column [1]. The experiments fall into three groups: first a straightforward replication of the 1985 exercise, then two modified replications which allow for more flexible adjustment of the money wage rate and the nominal exchange rate; and then three experiments which recycle all or part of the additional revenues from ECNZ profits back to the private sector - a procedure which attempts to isolate the allocative effects of the price shock by neutralising its income effects.

Replicating the 1985 Study

The first experiment used the new version of the model to replicate the 1985 study as closely as possible. The results appear in Column [2] of Table 1 and can be compared directly with the 1985 figures in Column [1], even though the new version of the model uses a more sophisticated solution routine than the old one. (The 1992 runs use a three stage procedure plus extrapolation to remove linearisation errors as far as possible, in contrast to the one-stage solution used in the 1985 study).

There is a close correspondence between the two sets of results for employment, output, price and exports. In the 1992 version GDP falls 1.0% as against 1.1% in the 1985 model, while labour demand falls 1.8% (cf 1.7% in the 1985 study), consumption falls 1.0% (cf 1.2%), real exports fall 1.8% (cf 2.3%), nominal exports fall 1.2% (cf 1.6%), and nominal imports fall 0.4% (cf 0.9%). On the price side the Consumer Price Index, and hence the money wage rate, rise 0.9% in the 1992 experiment (compared to 1.1% in 1985); the GDP deflator rises 0.9% (1.2%); and the local price of export products rises 0.6% (0.8%). The detailed volume effects on exports and

output by sector suggest somewhat less severe effects on the pulp and paper sector in the updated model, but more severe effects on basic metals (where the expansion of New Zealand Steel during the 1980s increased the weight of steel and reduced that of aluminium). The 1992 results for mining and energy exports bear no resemblance to the 1985 results, due evidently to the disaggregation of the mining sector in the 1985 study. Fortunately these two sectors carry little weight in the overall export picture.

The most significant difference between the 1985 and 1992 results lies in the Government sector. In the 1985 study the increased revenues to Government from increased ECNZ sales income were outweighed by the loss of income tax revenue as the tax base shrank, and the increase in unemployment-benefit transfers. As a result the budget deficit worsened. In the 1992 experiment #E1, real revenues rise ahead of expenditures, strengthening the budget balance by a net $15.4 million. The reason appears to be the declining share of direct taxes in total Government revenues as a result of changes to the tax system in the second half of the 1980s. Table 2 sets out the proportional composition of Government revenue and expenditure in the old and new versions of the JOANNA model, with the old database reflecting the 1981/82 tax system and the new database incorporating the 1991 composition of revenues and expenditure. Direct taxes, it can be seen, fell from 67% to 57% of total revenues, while GST and other indirect taxes moved up from 27% to 32% and "other revenue" (which includes SOE profits) rose from 6% to 11%. The shift from progressive income tax to flat-rate GST made Government revenue, and hence the budget balance, less sensitive to movements in GDP than previously, and this accounts for the reversal of sign between the 1985 and 1992 studies.

While the new results suggest that a 25% electricity price rise would make some headway in reducing the budget deficit, it is important to put the $15.4 million reduction in the deficit in context. The GFS financial deficit of the New Zealand Government in the 1986/87 year was $1.9 billion, while total revenue for that year was $17,408 million (Caygill 1989 pp.121 and 127). The 25% increase in electricity price would reduce a deficit of this magnitude by only 0.8%, at the cost of a 1% fall in GDP and a 1.8% fall in employment. Compared with other revenue-raising options, the model suggests that an electricity price increase carries relatively heavy penalties in terms of reduced economic activity, primarily because of its cost impact on traded-goods producers. The case for such a price increase, therefore, would still have to rest mainly on its allocative effects rather than on the desire of Government simply to raise revenue.

Replication with Modifications

Two experiments (#E5 and #E6) were conducted with the updated version of the model but using alternative 'closure' assumptions about the adjustments that are permitted to occur in the model economy on the way to the new general equilibrium. In the first experiment (Column [3] of Table 1) the money wage was held fixed and the real wage allowed to vary, with the result that the model was permitted to transfer part of the effects of the electricity-price squeeze away from profits to real labour costs. As a result the loss of competitiveness was greatly reduced, the fall in GDP was

brought back to 0.7%, the fall in real exports to 0.5%, and the fall in labour demand to 1.1%. The balance of payments current account emerged strengthened to the tune of $38.5 million, due both to stronger export performance than in the simple replication of Column [2], and to a further cut in household consumption, and hence in import demand, resulting from the fall in real wage income. The Government budget deficit emerged stronger by $165 million (due largely to the smaller increase in unemployment benefit payments).

A further experiment (Column [4] of Table 1) allowed the nominal exchange rate also to vary, while requiring the model to keep the balance-of-payments current account fixed at the business-as-usual level. This is an attempt to meet the idea that over time, the economy's real exchange rate has some tendency to re-establish a 'normal' level following any disturbance. The nominal exchange rate, however, plays only a small role in this process in the present experiment, because the real-exchange-rate depreciation resulting from holding the money wage rate fixed (see previous paragraph) has already strengthened the balance of payments so much that a small appreciation of the nominal exchange rate is required to bring the current account back to its business-as-usual level,. This appreciation accounts for the worsening in the position of some traded-goods sectors (including pulp and paper and basic metals), and the additional fall in GDP and labour demand, between Column [3] and Column [4] of Table 1.

Three Experiments with Revenue Recycling

Revenue recycling is now standard practice in overseas modelling work on energy price shocks, for two basic reasons. The first is a desire to focus on the allocative effects of carbon taxes, energy levies and the like, in abstraction from the income effects of a net increase in first-round Government revenues. The second is the wish to avoid having to embark on analysis of the monetary implications of changes in the Government's overall budgetary position - a task for which computable general-equilibrium models are not well suited. It is also worth noting that many actual policy proposals for carbon taxes now see them as substituting for existing taxes on income, assets or expenditure rather than as expanding the size of the government sector (see for example Common 1992).

Insofar, thus, as increased prices or taxes on energy bring in additional revenue to Government, the model can be instructed to return this revenue to the private sector through some identified channel, leaving Government (and its budget balance) as a passive bystander, while the private sector adjusts its economic transactions in accordance with the new distribution of incomes and set of relative prices. In the OECD's GREEN model, for example (Burniaux et al 1992 p.12),

> changes in the government budget induced by carbon tax revenues are compensated by offsetting changes in the marginal income tax rate. This approximates revenue-neutrality, which is considered the appropriate closure to apply to the government sector for long-term simulations.

It has recently become apparent that the results of model experiments using this assumption are

highly sensitive to the choice of recycling channel - a major issue in the future design of carbon tax systems. Shackleton et al (1992, cited in Dower and Zimmerman 1992 p.16) found that a $40 per ton carbon tax, with all revenues returned to the private sector over a twenty-year modelling horizon, would lead to a 1.5% GNP fall relative to business-as-usual if the recycling was done by lump-sum redistribution to private households, or to a 1% rise in GNP if recycling was done by reducing taxes on capital. The JOANNA experiments reported in Columns [5]-[7] of Table 1 cast light on this issue in the New Zealand context.

In the first experiment (Column [5]), only partial revenue recycling was undertaken. Rather than assuming revenue-neutrality for Government, this experiment returned enough revenue via income-tax cuts to leave the household sector's disposable income, and hence real consumption expenditure, unchanged from business-as-usual. Apart from this modification, the closure of the model was identical to that used for the simple replication exercise in Column [2] of Table 1. Differences between the two sets of results are thus attributable to the recycling assumption.

Intuitively it is obvious that boosting private consumption with the proceeds of an excise tax on a major industrial input would be likely to boost GDP, but to put pressure on the balance of payments. (The process is equivalent, in fact, to a redistribution from profits to wages.) This indeed is the result which emerges from the model: with consumption held constant in place of the 1% fall of Column [2], the falls in GDP and labour demand are reduced (to 0.75% and 1.44% respectively) but real exports now fall by 2.4% and the balance of payments current account worsens by $287 million. Government revenues fall in real terms, and the budget balance weakens by $126 million. Meantime money wage rates rise 1% rather than 0.9%, intensifying the squeeze on the competitiveness of traded-goods producers.

The other two revenue-recycling experiments (Columns [6] and [7] of Table 1) returned all of the additional ECNZ revenue to the private sector. This was done first by reducing the rate of income tax (#E3), and then by reducing the rate of GST (#E4). (The device used was to add to the model two 'wedge' variables: fTAXCOE, the shift in tax on compensation of employees, and fGST, the shift in the GST rate.) The differences in results between these two recycling options are dramatic. Revenue recycling via income tax cuts, in the context of a 25% electricity price increase, generates consumption growth of 0.6% with GDP still falling 0.6% (Column [6]). Not surprisingly, this weakens both the balance of payments and the government budget balance, with money wage rates, the Consumer Price Index and the GDP deflator all moving up. Real exports now fall by 2.8% with volume reductions spread across all commodities. The combination of falling exports with rising imports (driven by consumption spending) results in a $382 million worsening of the balance of payments current account, while the government budget balance deteriorates by $209 million.

In contrast, recycling via a GST reduction greatly reduces the contractionary squeeze on GDP (only a 0.2% fall) and leads to only a modest 0.36% drop in real exports, with several export sectors actually showing volume growth. The balance of payments current account falls only $26

million compared with $382 million in the previous experiment, while the Government budget balance emerges stronger by $5 million. The much stronger performance of the economy under this recycling assumption is explained by the fall in the Consumer Price Index, and the associated restraint of money wages (given the assumption of a fixed real wage).

The very great sensitivity of the results to the choice of recycling channel is clearly a major issue deserving more work. A follow-up study on this issue is in preparation.

Visual Presentation of Results

Figures 1 - 3 at the end of this paper provide a visual comparison of the 1985 Run #10L with the six new JOANNA experiments discussed in this paper, numbered #E1 to #E6. The charts show the results in the same order as they appear in Table 1. Separate shadings are used to identify the 1985 results, the 1992 replication and its variants, and the three 1992 revenue-recycling experiments.

Conclusion

This paper has reported the results of work which used a recently-updated version of the JOANNA model to repeat and extend the 1985 BERL study of the economy-wide implications of a 25% electricity price shock. The 1985 findings were successfully replicated with the exception of the government budget balance, which emerged stronger in the 1992 results rather than weaker as in the 1985 study. This sign reversal is attributed to the increased importance of indirect taxes (including GST) in the composition of government revenue, and the resulting reduced impact of GDP changes on the budget balance.

Supplementary experiments in which the money wage rate and the nominal exchange rate were allowed to vary showed that restoring the economy's overall competitiveness by these means still left certain traded-goods sectors significant losers, especially pulp and paper and basic metals, while the lower real wage required to restore overall competitiveness meant reduced household consumption, and hence lower living standards. The reduced income-tax base and higher unemployment benefit payments which result from treating the electricity price as a revenue-raising device both erode the gains to the budget balance, but under the tax structure prevailing at the end of the 1980s the government still emerges as a net gainer from profit-taking by a monopolist state-owned electricity generator, even with the model's economy-wide feedbacks taken into account.

Preliminary investigation of the issue of revenue recycling pointed to the need for systematic research into the implications of choosing alternative channels to 'revenue neutrality'. Full exploration of this issue lies beyond the scope of the present paper.

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Table 1: JOANNA Runs for 25% Electricity Price Shock

	JOANNA variable(s)	[1] 1985 run #10L	[2] Run #E1 Replicates 1985 using 1986/87 database	[3] Run #E5 =#E1 except: nominal wage exogenous	[4] Run #E6 =#E1 except: nominal exchange rate endogenous, BoP fixed	[5] Run #E2 =#E1 except: income tax rate endogenous, household Yd fixed	[6] Run #E3 =#E1 except: endogenous income tax cut to return revenue	[7] Run #E4 =#E1 except: endogenous GST cut to return revenue
NATIONAL ECONOMY								
Labour demand	xTOTFAC1	-1.74	-1.79	-1.12	-1.28	-1.44	-1.23	-0.36
Real GDP	xGDP	-1.1	-1.04	-0.68	-0.76	-0.75	-0.59	-0.20
Real private consumption	xTOT1	-1.16	-1.04	-1.15	-1.12	0.00*	0.61	-0.20
Real exports	xTOT5	-2.34	-1.79	-0.49	-0.79	-2.43	-2.81	-0.36
Value of exports	nTOTXPT	-1.58	-1.22	-0.33	-0.54	-1.66	-1.93	-0.24
Value of imports	nTOTMPT	-0.9	-0.38	-0.59	-0.54	0.25	0.62	-0.07
Nominal exchange rate	phi	0.0*	0.0*	0.0*	-0.21 (c)	0.0*	0.0*	0.0*
Change in b.o.p. current account: 1981/82 prices	dTRADE	-$45.6 m						
Change in b.o.p. current account: 1986/87 prices	dTRADE	-$65.1 m**	-$125.9 m	+$38.47m	0.00*	-$286.86m	-$381.59m	-$25.87m
Nominal Government revenues	gREVTOT		1.37	1.11	0.96	0.78	0.44	-0.48
Nominal Government expenditure	gPAYTOT		1.33	0.42	0.42	1.35	1.37	-0.46
Real Government revenues	gREVTOT-pTOT1	-0.3	0.52	0.95	0.85	-0.21	-0.64	0.67
Real Government payments	gPAYTOT-pTOT1	0.38	0.48	0.26	0.31	0.36	0.29	0.69
Change in budget balance: 1981/82 prices	dGOVBUD	-$87.2 m						
Change in budget balance: 1986/87 prices	dGOVBUD	-$150.6 m***	$15.4 m	$164.6m	$129.5m	-$125.7m	-$208.5m	$5.0m
EXPORTS OF PRODUCTS								
Pulp and paper	xXPT9	-7.32	-4.97	-2.96	-3.44	-6.00	-6.59	-2.81
Mining	xXPT11	-5.69	0.37	1.27	1.06	-0.64	-1.23	0.79
Base metals	xXPT14	-5.63	-8.09	-6.61	-6.96	-9.06	-9.63	-6.72
Energy	xXPT10	-4.68	-0.20	0.30	0.18	-0.59	-0.81	0.22
Fish	xXPT5	-3.77	-2.22	-0.17	-0.65	-3.19	-3.77	0.07
Food, beverages and tobacco	xXPT6	-3.68	-2.94	-0.77	-1.28	-3.95	-4.54	-0.50
Other manufactured	xXPT16	-3.54	-2.37	-0.43	-0.88	-3.37	-3.95	-0.28
Chemicals	xXPT12	-3.37	-2.16	-0.41	-0.82	-3.12	-3.68	-0.34
Services	xXPT17-19	-2.99	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Tourism	xXPT17		-1.90	0.21	-0.29	-2.88	-3.45	0.48
Transport	xXPT18		-1.50	0.61	0.11	-2.41	-2.94	0.96
Other services	xXPT19		-1.26	0.90	0.39	-2.40	-3.06	1.04
Wood products	xXPT8	-2.86	-1.47	0.34	-0.08	-2.58	-3.23	0.30
Ceramics	xXPT13	-2.57	-2.48	-0.67	-1.10	-3.55	-4.17	-0.67
Fabricated metals	xXPT15	-2.47	-2.45	-0.63	-1.06	-3.27	-3.76	-0.38
Textiles and garments	xXPT7	-2.42	-2.57	-0.47	-0.96	-3.48	-4.02	-0.15
Horticulture	xXPT4	-1.18	-1.19	-0.25	-0.47	-1.60	-1.85	-0.10
Dairy	xXPT1	-0.83	-0.64	-0.20	-0.30	-0.85	-0.97	-0.14
Meat	xXPT2	-0.83	-0.65	-0.21	-0.31	-0.86	-0.98	-0.15
Wool	xXPT3	-0.59	-0.57	-0.12	-0.22	-0.76	-0.88	-0.05
SECTORAL OUTPUT								
Pulp and paper (a)	z8 (a)	-4.07	-2.23	-1.47	-1.65	-2.15	-2.10	-0.93
Base metals	z11	-2.96	-6.03	-4.87	-4.14	-6.57	-6.89	-4.73
Transport and storage	z18	-1.88	-1.55	-0.47	-0.72	-1.71	-1.80	0.01
Printing and publishing	(a)	-1.85	(a)	(a)	(a)	(a)	(a)	(a)
Electricity	z14	-1.64	-1.62	-1.33	-1.40	-1.24	-1.02	-0.77
Ownership of dwellings	z21	-1.62	-1.53	-1.70	-1.66	0.21	1.23	-0.02
Logging & forestry	z3	-1.54	-1.24	-0.77	-0.88	-1.05	-0.94	-0.31
Other manufacturing	z13	-1.47	-1.92	-0.77	-1.04	-2.12	-2.24	-0.28
Fishing & hunting	z2	-1.34	-1.42	-0.39	-0.63	-1.72	-1.89	-0.07
Textiles, apparel, leather	z6	-1.34	-1.29	-0.54	-0.72	-1.31	-1.32	-0.11
Chemicals, oil, rubber, plastics	z9	-1.34	-1.29	-0.74	-0.87	-1.08	-0.95	-0.19
Gas & water	z15	-1.34	-1.30	-1.03	-1.10	-0.79	-0.49	-0.40
Communications	z19	-1.34	-1.19	-0.74	-0.85	-0.91	-0.75	-0.19
Trade, restaurants, hotels	z17	-1.28	-1.13	-0.86	-0.93	-0.64	-0.36	-0.20
Finance, insurance etc	z20	-1.27	-1.18	-0.83	-0.91	-0.62	-0.30	-0.12
Private services	z22	-1.24	-1.25	-1.10	-1.14	-0.30	0.26	-0.02
Fabricated metals	z12	-1.19	-1.48	-0.85	-0.99	-1.40	-1.36	-0.39
Non-metallic mineral products	z10	-1.13	-0.81	-0.52	-0.59	-0.69	-0.61	-0.25
Agriculture	z1	-1.07	-1.06	-0.46	-0.60	-1.09	-1.11	-0.13
Food, beverages, tobacco	z5	-1.07	-0.99	-0.50	-0.62	-0.94	-0.91	-0.15
Wood & wood products	z7	-1.05	-1.04	-0.64	-0.73	-0.89	-0.81	-0.28
Construction	z16	-0.31	-0.42	-0.32	-0.34	-0.29	-0.21	-0.15
Public services	z23	-0.11	-0.11	-0.08	-0.09	-0.05	-0.02	-0.01
Mining & quarrying	z4	(b)	-1.19	-0.69	-0.81	-1.16	-1.13	-0.35
Coal mining		-2.07	(b)	(b)	(b)	(b)	(b)	(b)
Mining & quarrying nec		-2.36	(b)	(b)	(b)	(b)	(b)	(b)
Oil & natural gas		-0.25	(b)	(b)	(b)	(b)	(b)	(b)
PRICES								
Consumer price index	pTOT1	1.12	0.90	0.55	0.42	1.02	1.09	-0.42
Capital goods prices	pTOT2	0.37	0.49	0.19	0.05	0.65	0.74	0.16
Money wage rates	pLAB	1.12	0.90	0.00*	0.00*	1.02	1.09	-0.42
Real wage rates	fWAGE	0.00*	0.00*	-0.55	-0.42	0.00*	0.00*	0.00*
Local price of export products	pTOT5	0.76	0.58	0.16	0.05	0.79	0.91	0.11
GDP deflator	pGDP	1.18	0.94	0.43	0.34	1.13	1.24	-0.38
Economy-wide rate of return	rAVGCAP		-2.10	-1.73	-1.81	-1.75	-1.55	-1.17

(a) Printing and publishing included in z8 for the new runs; disaggregated in 1985 run.
(b) Mining & quarrying disaggregated in 1985 run.
(c) Nominal exchange rate is defined as the price of foreign exchange; hence minus sign signifies appreciation.

* indicates variables held fixed in order to solve the model.
** Deflated using import price index
*** Deflated using GDP deflator.

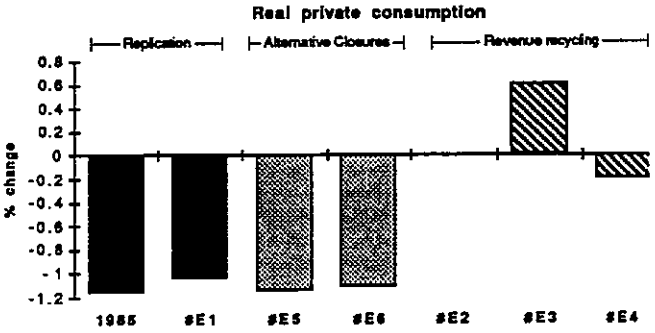
Table 2

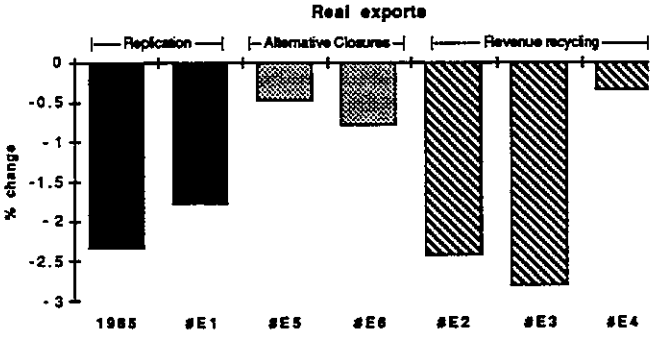
Proportional composition of Government revenue and expenditure in the JOANNA Model

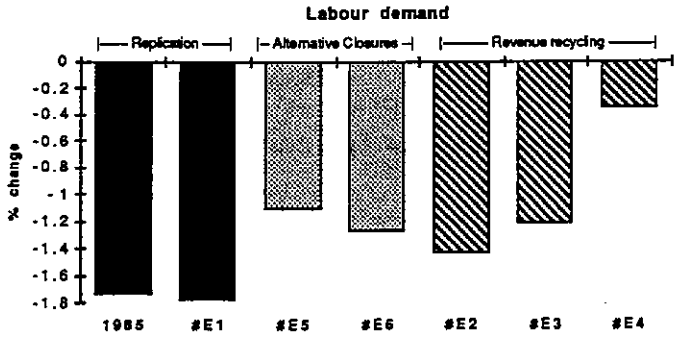
	1981/82 database	1986/87 database
GOVERNMENT REVENUE		
Direct taxes	0.6685	0.5730
GST and other indirect taxes	0.2672	0.3163
Other revenue	0.0644	0.1108
Total	**1.0000**	**1.0000**
GOVERNMENT EXPENDITURE		
Wages and salaries	0.3314	0.2607
National Super/GRI	0.1773	0.2063
Unemployment benefit	0.0222	0.0563
Other benefits	0.0681	0.0642
Debt servicing	0.0786	0.0788
Other	0.3224	0.3338
Total	**1.0000**	**1.0000**

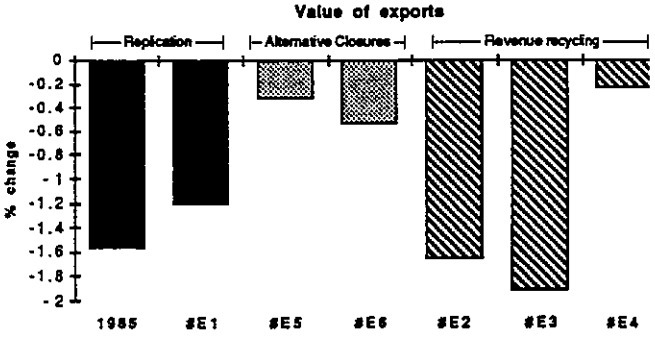
Figure 1

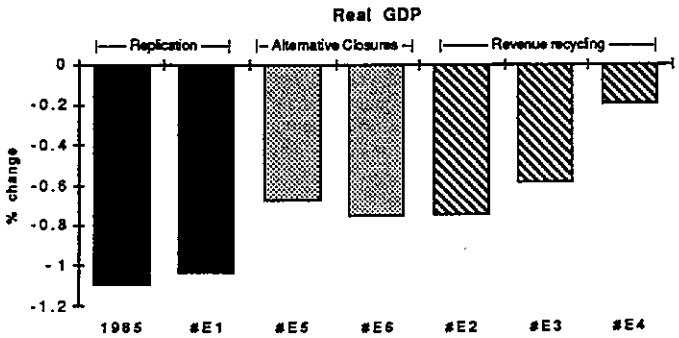
Effects on Macroeconomic Aggregates of a 25% Electricity Price Increase in the 1985 Study and in the Six 1992 JOANNA Runs

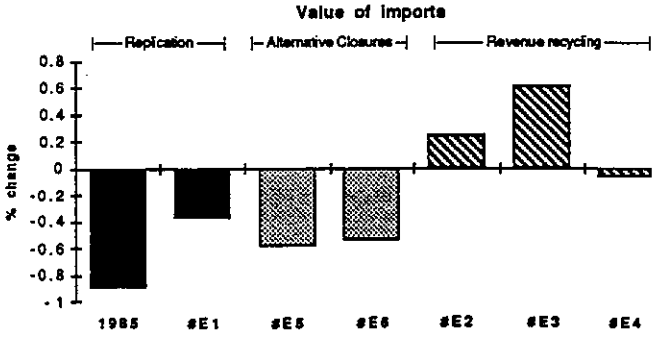












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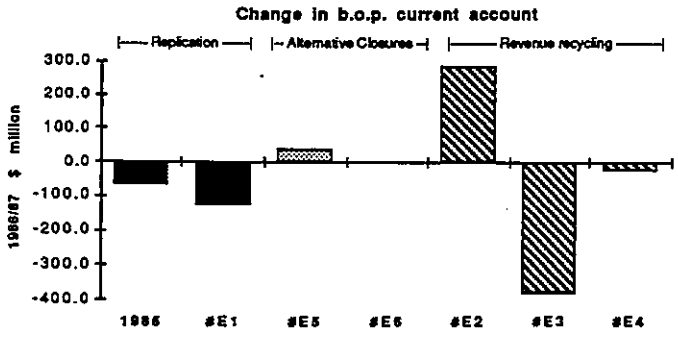

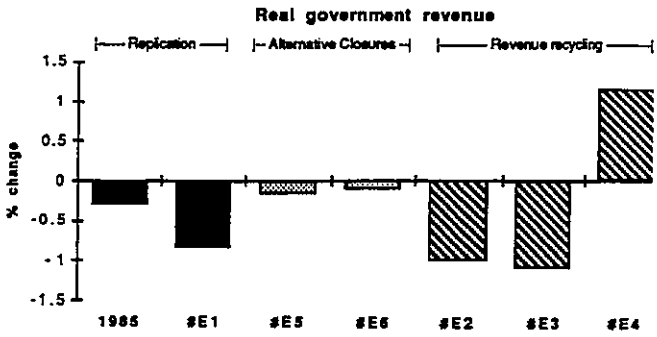

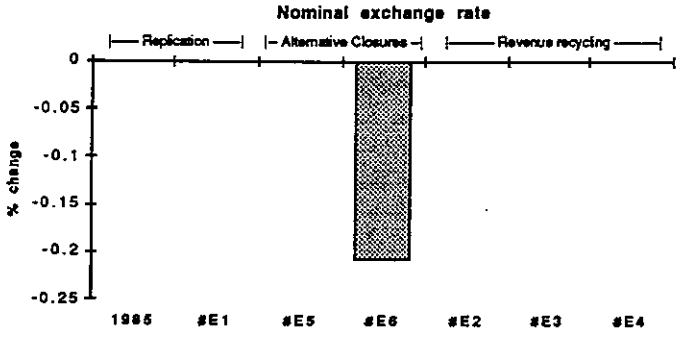

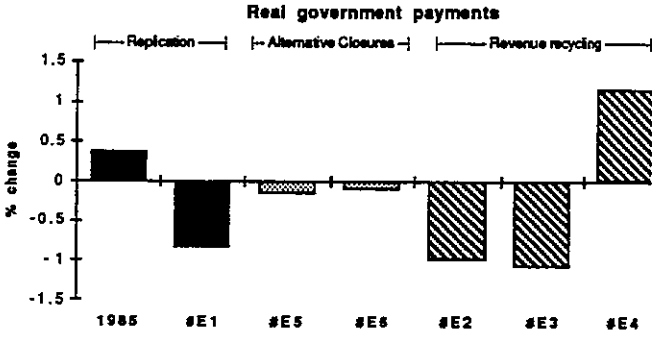

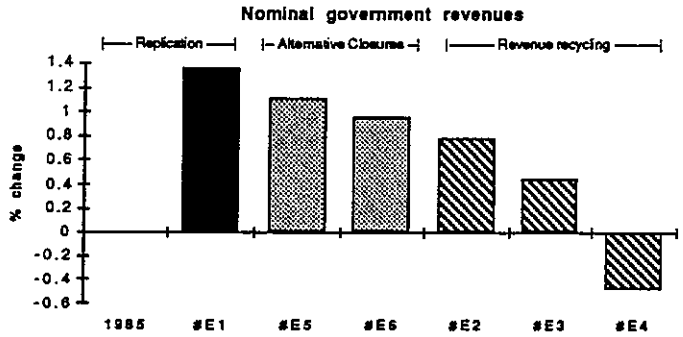

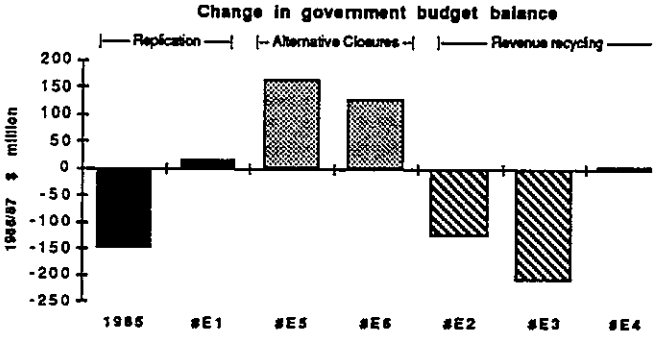

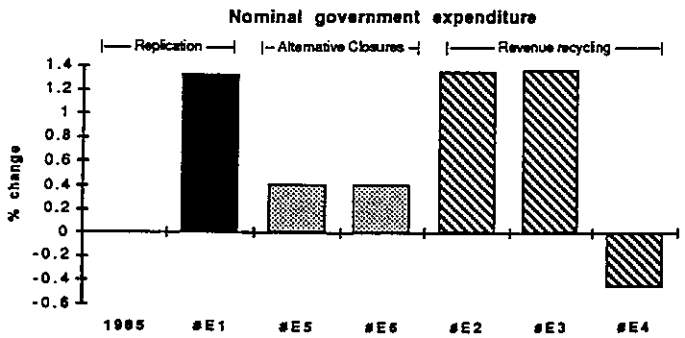

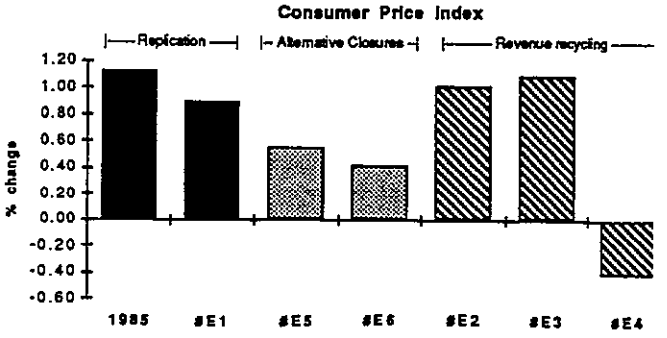

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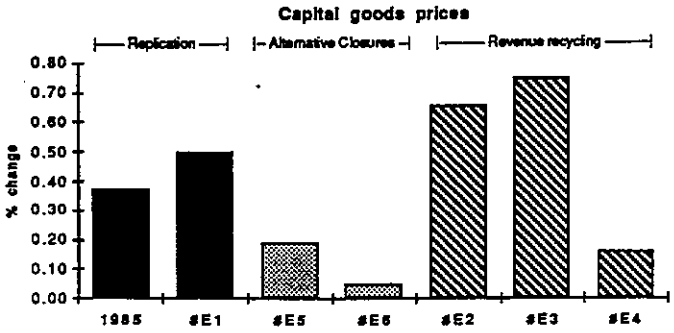
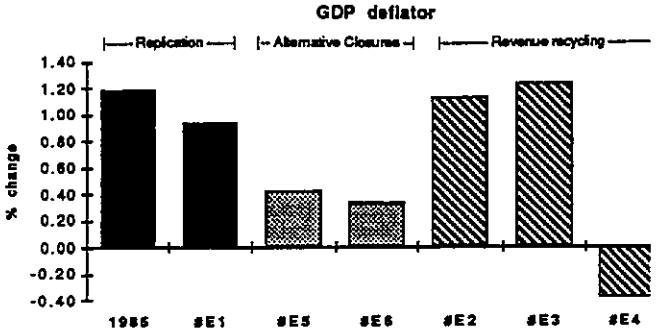
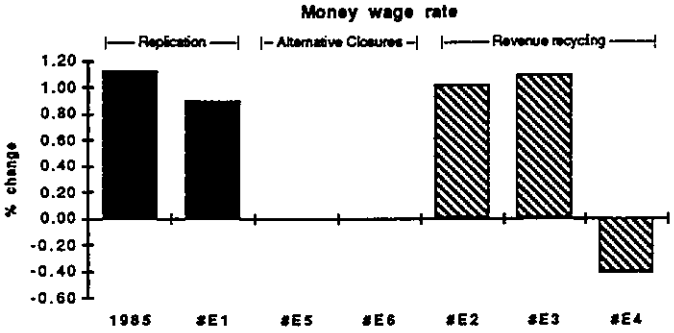
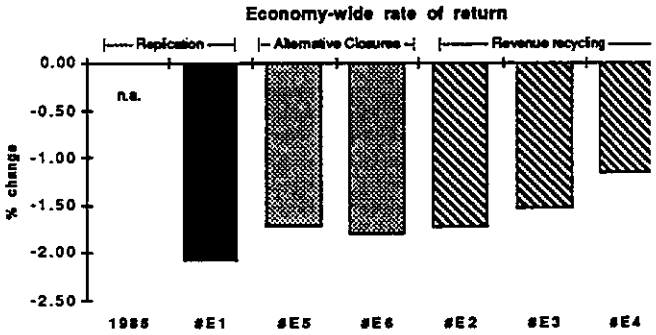
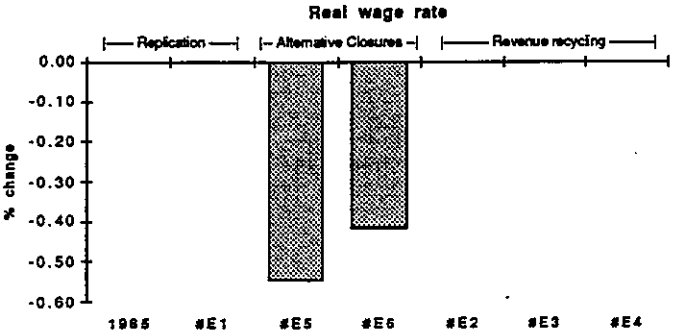










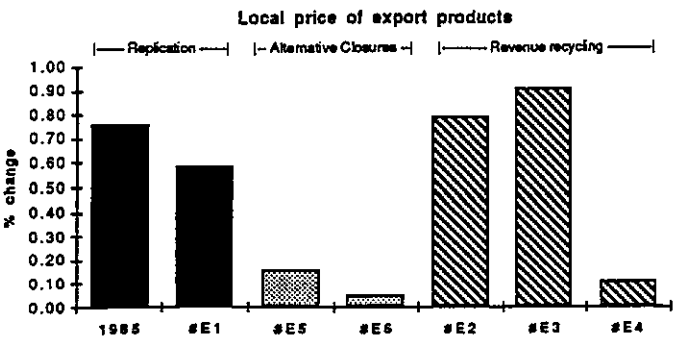
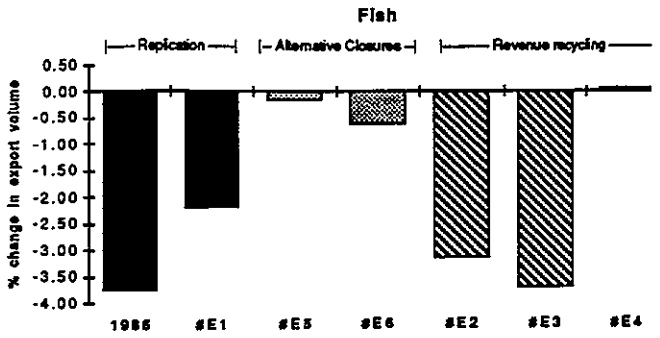
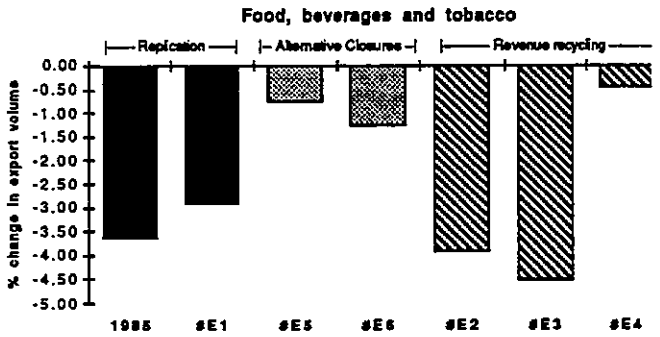
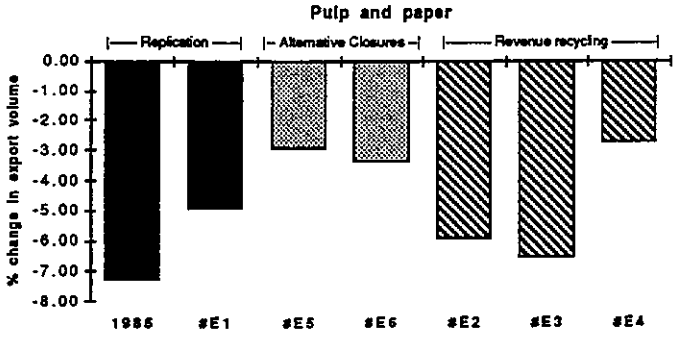


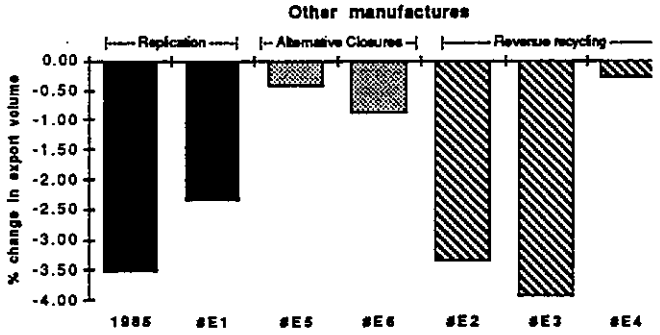
Figure 2

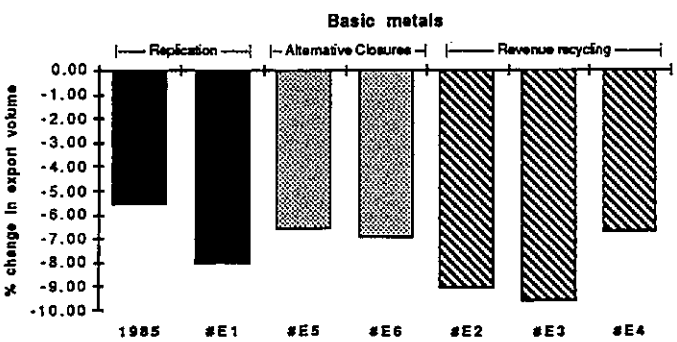
Changes in Export Volume, By Commodity, Resulting from a 25% Electricity Price Increase in the 1985 Study and in the Six 1992 Experiments

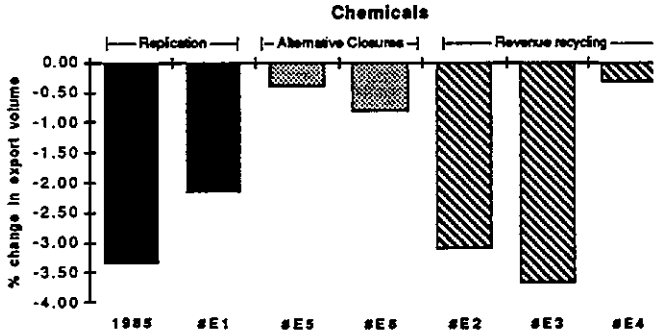












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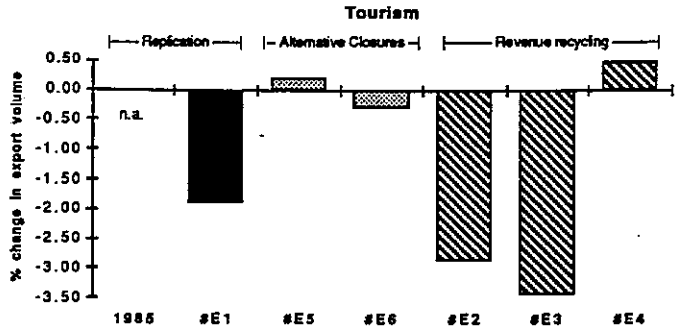

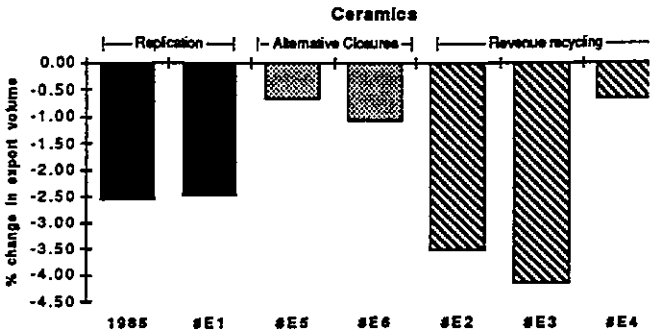

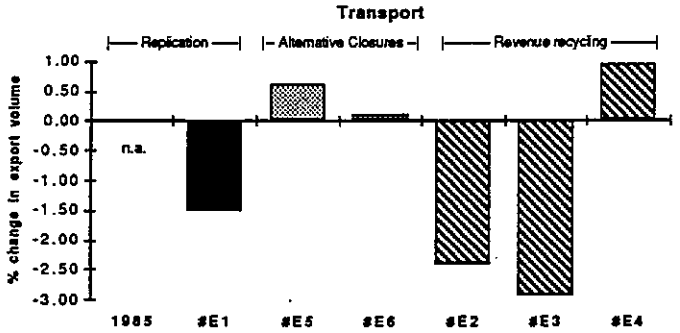

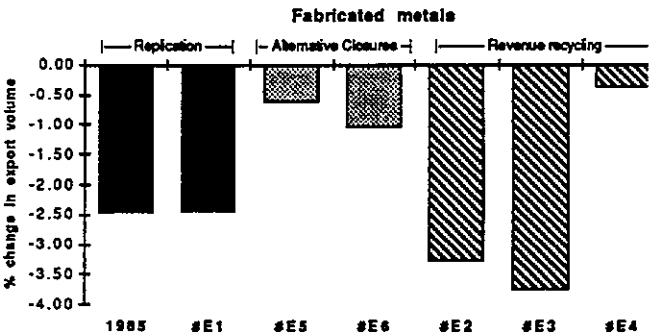

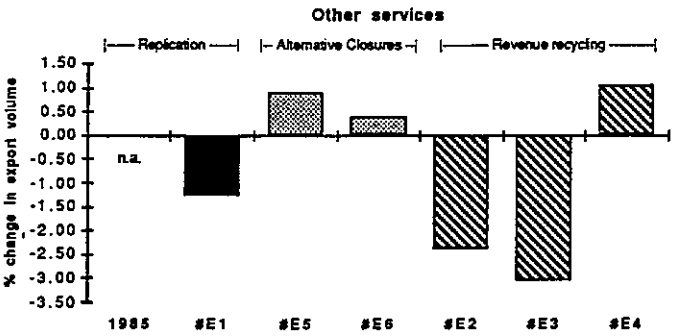

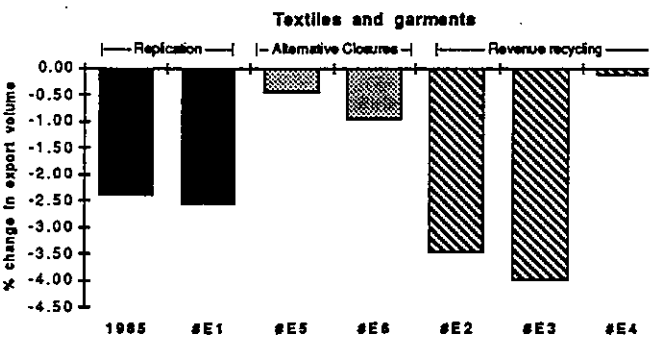

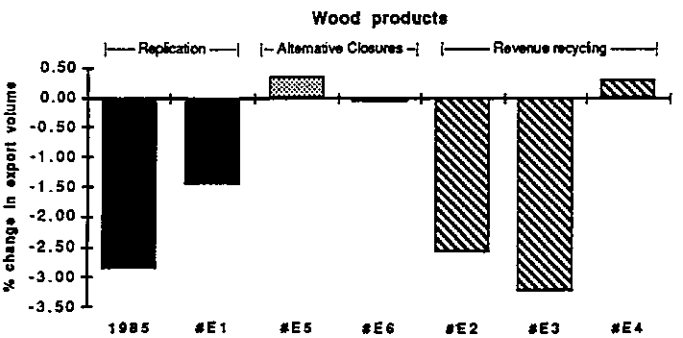

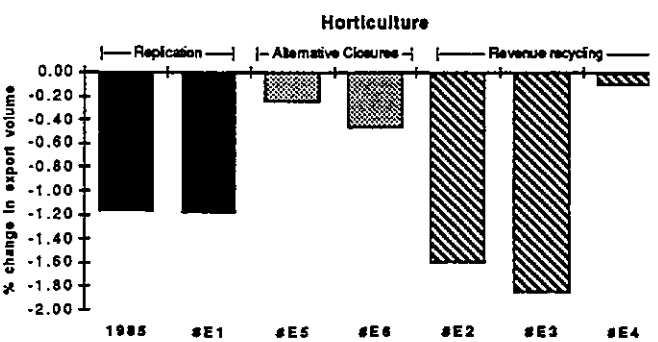

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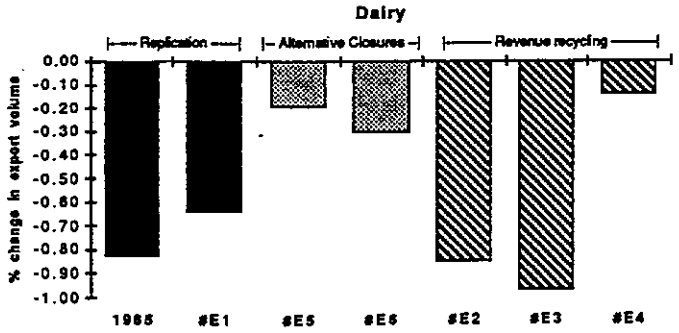
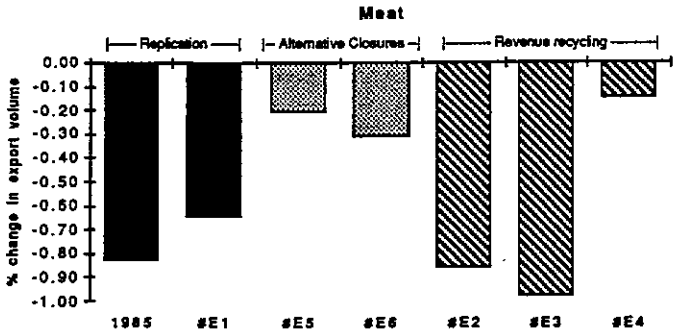




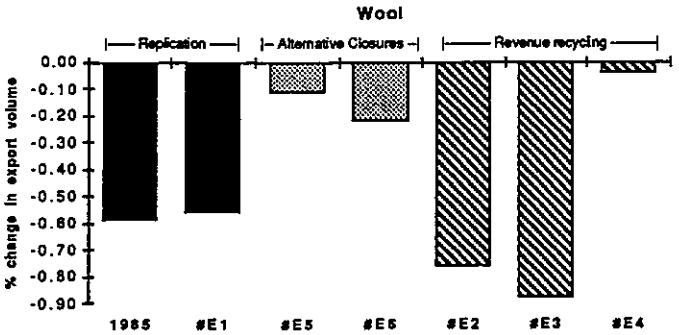
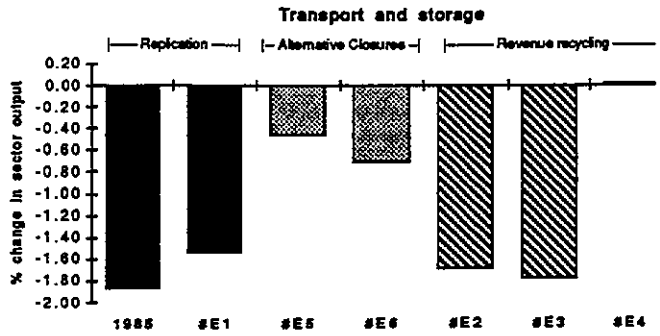
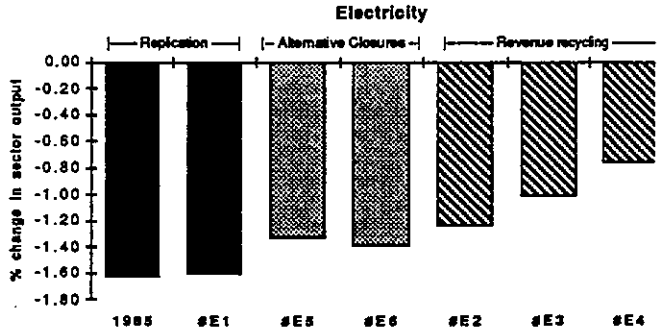
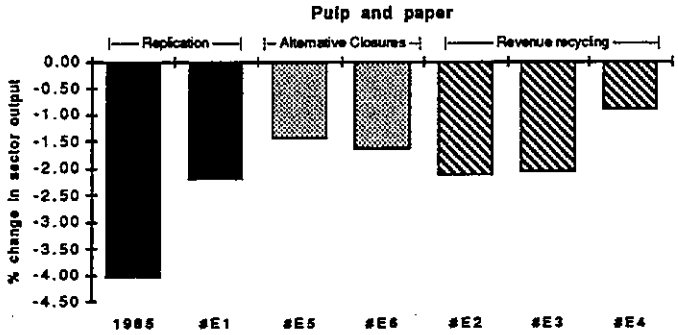


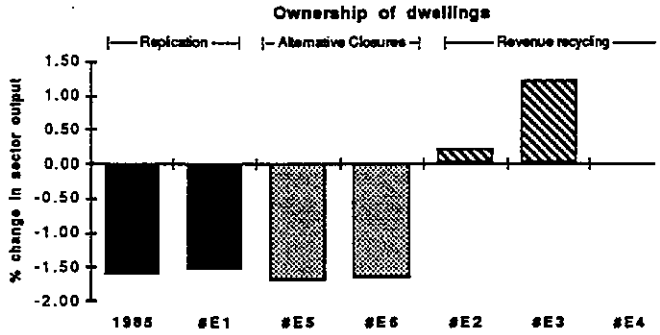
Figure 3

Effects on Output of a 25% Electricity Price Increase in the 1985 Study and in the Six 1992 JOANNA Runs

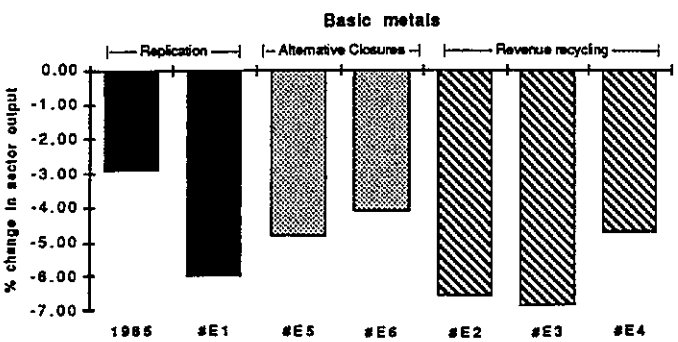


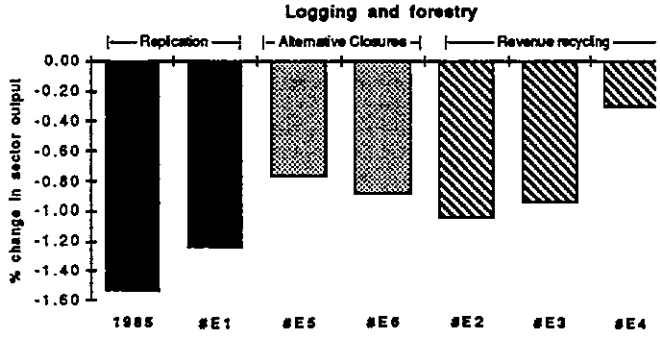






Note: Excludes printing & publishing in 1985 study; see note a to Table 1.





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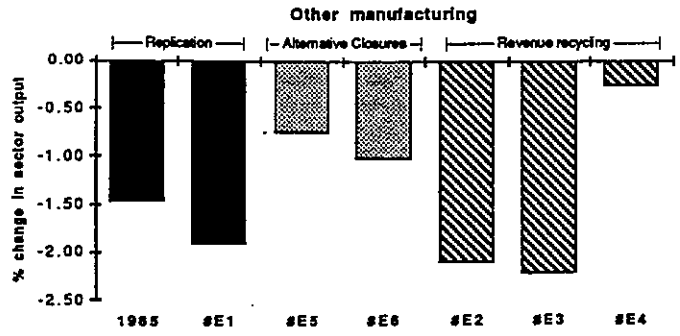

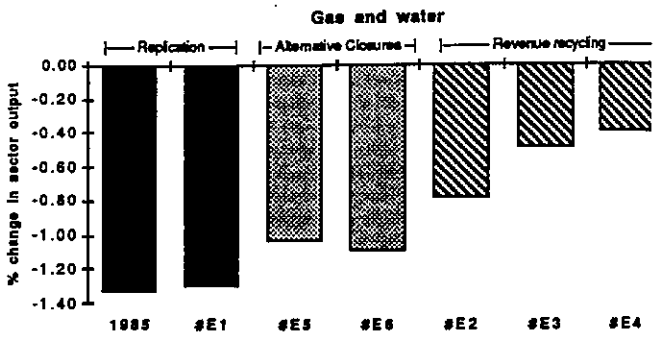

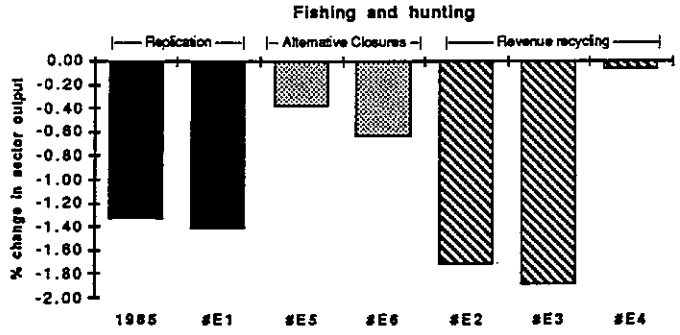

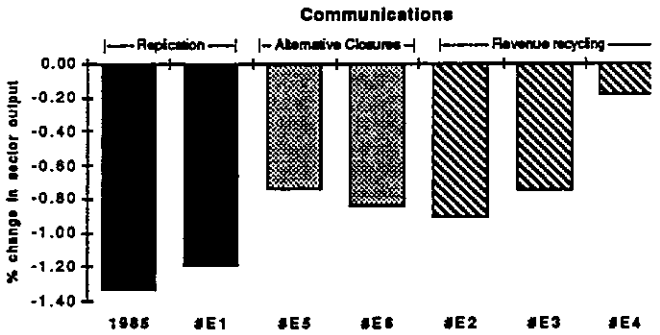

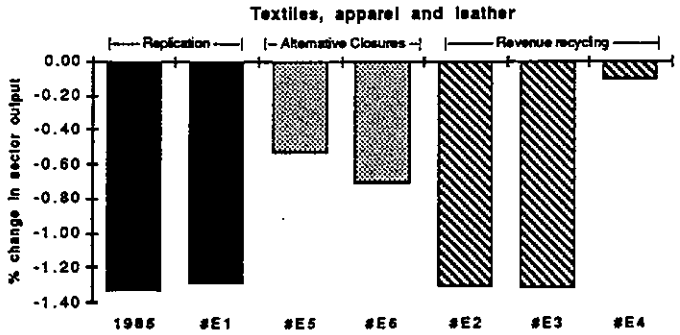

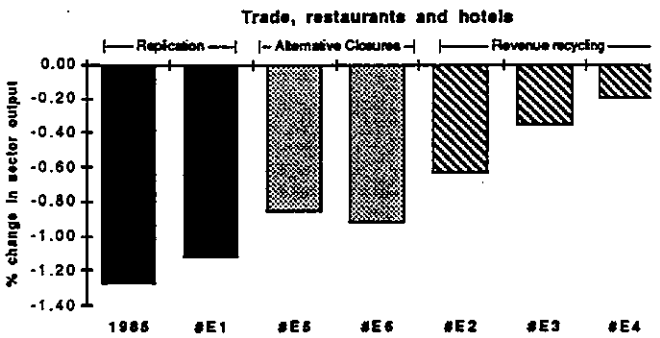

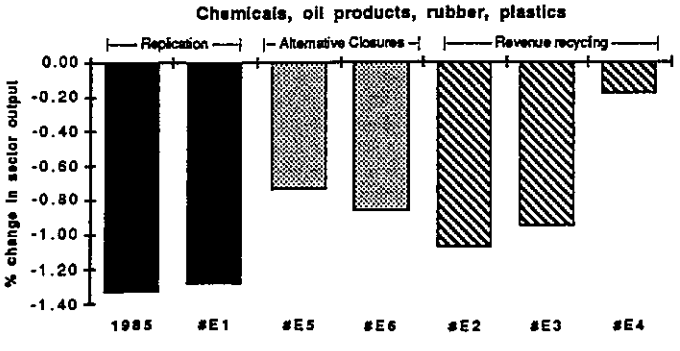

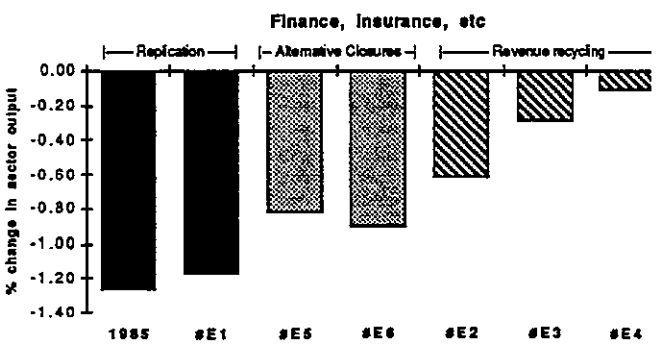

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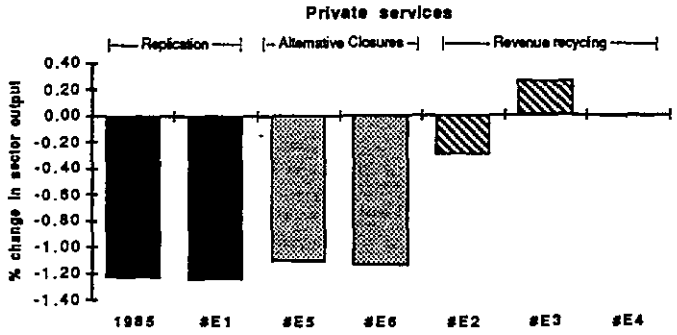

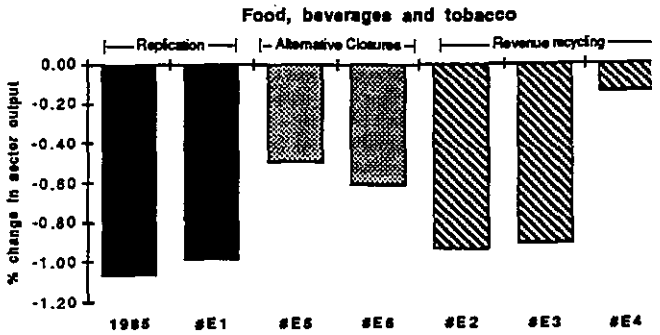

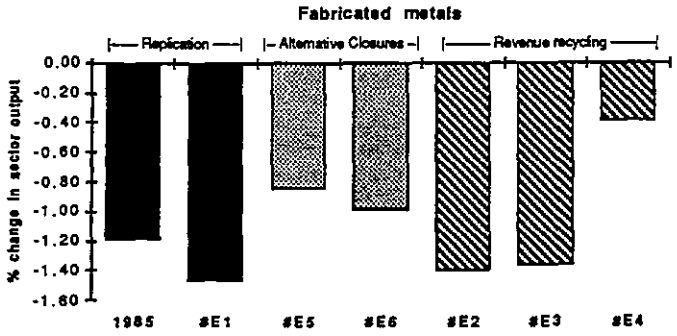

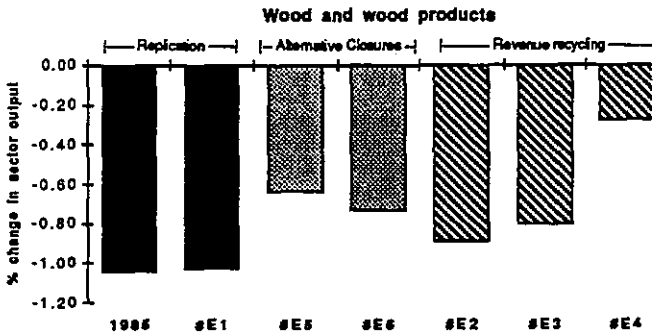

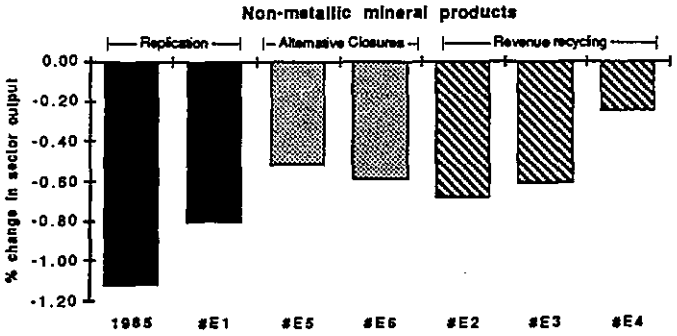

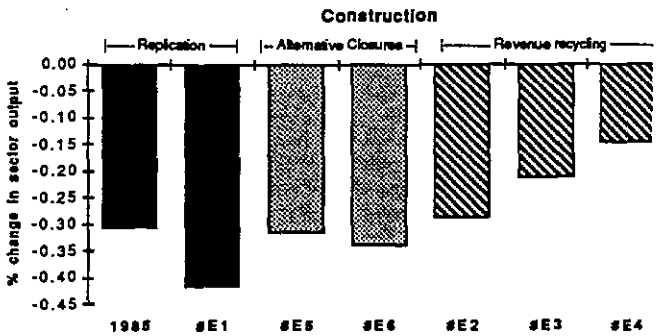

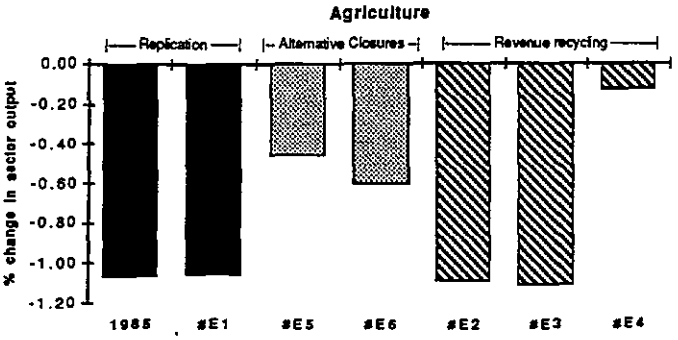

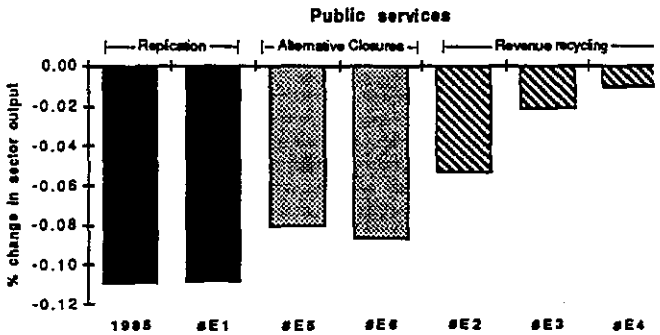

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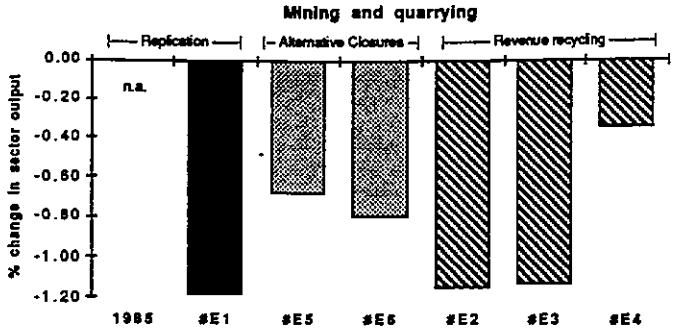

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