EUROPEAN UNIVERSITY INSTITUTE, FLORENCE
DEPARTMENT OF ECONOMICS

EUI WORKING PAPER No. 86/225

WAGE-EARNERS' INVESTMENT FUNDS:
THEORY, SIMULATION AND POLICY

by

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This paper was prepared while the author was visiting the European University Institute, to work on the project "The Effects of Workers' Participation Schemes in Western Europe".

BADIA FIESOLANA, SAN DOMENICO (FI)
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Printed in Italy in June 1986
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1. Introduction

A wage-earners' investment fund is a form of collective ownership of capital which raises income from taxation and uses it to acquire shares on behalf of wage-earners. Such funds have been discussed in Western Europe during the 1970's and 1980's (Denmark (1973, 1979), West Germany (1974), Holland (1976), Sweden (1974, 1983), United Kingdom (1974)). The Swedish 1983 plan was implemented in December 1983.

For a discussion of the various institutional arrangements see George (1985b). The theory of such funds is discussed in George (1985a), Brems (1975a,b,c) and Kristofferson (1981) while Meidner (1978) provides an excellent account of the Swedish debate up to 1975.

Discussions of wage-earners' investment funds have normally been stimulated by the problems of ensuring efficient capital accumulation in highly unionised economies operating near full-employment. In such an economy wage-pressure can damage profitability and hence accumulation, or can be inflationary, or both. Deflationary policies are highly costly in terms of lost output and "union-busting" policies are likely to be unworkable in practice and unacceptable in principle. Unions may perceive the need for wage-restraint but argue that the benefits of such restraint should accrue, at least partially to them and not solely to owners of capital. Wage-earners' investment funds provide a means by which union wage-restraint can generate an increased measure of worker
influence over the accumulation process, as a quid pro quo for that restraint.

Such influence may well lead to increasing worker influence on the production process itself. This could take the form of codetermination within otherwise conventional firms or of the direction of resources towards participatory firms such as workers' cooperatives. It is a theme of the literature that accumulation in self-managed firms should be externally financed (see e.g. Vanek (1975)) and successful self-managed systems, such as the Mondragon cooperatives in Spain, typically do have an external funding agency. (In Mondragon it is a bank, the Caja Laboral Popular.) For a discussion of the relevance of wage-earners' funds to British economic policy see George (1985b).

Wage-earners' investment funds then provide a form of collective capital ownership in addition to orthodox nationalisation. Such a fund may provide a means to extend and develop a 'self-managed' sector within the economy and to promote worker-participation within conventional enterprises.

The kind of fund analysed in this paper is the kind described in the Danish 1973 proposal (Danish Government (1973)). This proposal formed the basis of the scheme suggested for the U.K. in the Labour Party's report "Capital and Equality" published in 1974 (Labour Party (1974)). Under the Danish 1973 proposal, the fund contributions are derived from a tax on the wage
bill. It is levied at a rate \( \alpha(t) \) (the contribution fraction) in year \( t \), with \( \alpha(t) \) rising linearly in the first \( T \) years of the fund's life and thereafter remaining constant. Individuals would hold non-negotiable fund certificates which could be redeemed after a minimum period of \( T \) years (the redemption period) at their fully accumulated value. In the Danish 1973 proposal the contribution fraction rose by \( \frac{1}{2} \% \) per year to reach a maximum of 5% after ten years, thereafter remaining constant. The redemption period was seven years. Of course wage-earners' would be free to continue holding their certificates beyond the redemption period and continue earning the going rate of return. Throughout this paper however, it will be assumed that all redemptions are made as soon as possible.

How successful a wage-earners' investment fund will be in achieving its policy objectives will depend, inter alia, on how much of the capital stock it owns. This paper provides an analysis of this question based on simulation methods. It also analyses the effects of varying the two key policy parameters, \( \alpha \) (the contribution fraction) and \( T \) (the redemption period).

2: A Simple Growth Model

The underlying theory of this paper is based on George (1985a). It involves a simple Pasinetti-type model (Pasinetti 1962, 1974) of capital accumulation and growth. The model reflects a world in which adequate investment is undertaken to fully employ a labour force.
Growing exogenously at a constant-exponential rate \( (g) \).

Any technical progress is Harrod-neutral and can therefore be subsumed in growth of the labour force.

The capital stock \((K)\) is owned either by business corporations \((K_c)\) or by the fund \((K_f)\). Although workers are assumed to save a small proportion of their incomes, this saving is treated as attracting a zero real rate of return. This reflects a situation in which workers' individual savings are made in forms which do not attract a rate of return above the rate of inflation. During the late 1970's, for example, many British building society deposits earned a negative real rate of return. The idea of a wage-earners' investment fund has been supported by arguments which turn on a kind of "economy of scale" in savings. Arrangements for workers' collective saving should generate a higher real rate of return than workers could secure individually. Throughout the paper the fund is assumed to make the same real rate of return on its capital as corporations do on theirs. Workers are assumed to make a zero real rate of return on their savings which are assumed to lead to the augmenting of corporations' capital \((K_c)\).

No consumption occurs out of business income and, following Pasinetti, the distribution of income is assumed to adjust so as to ensure macroeconomic equilibrium. The capital stock is assumed to depreciate at a constant rate \((\delta)\).

National income \((Y)\) either takes the form of wages \((W)\)
or profits (P):

\[ Y = W + P = wL + rK \]  

\[ (w = \text{real wage rate}, \ r = \text{real profit rate}) \]

Technology is of the fixed proportions variety:

\[ Y = \min (aK, bL) \]  

In the Pasinetti-world described above, labour, capital and output all grow at the exponential rate g and the capital labour ratio therefore remains constant:

\[ \frac{K}{L} = \frac{b}{a} = \rho \]  

Equations (1), (2) and (3) imply:

\[ aK = wL + rK \]

\[ \Rightarrow w = (a-r) \rho \]  

Equation (4) is a factor price frontier and macroeconomic equilibrium is ensured by movements along this frontier. Clearly:

\[ 0 \leq w \leq b, \ 0 \leq r \leq a \]  

It will be assumed that workers have a constant average propensity to consume (\( C_w \)) which is the same for wage as for redemption income. It can easily be seen that this assumption will ensure that the workers' share in national income is unaffected by the presence of the fund. Let \( Y_w, Y_f \) and \( Y_c \) be the incomes of workers, the fund and corporations respectively.
(Income shares will be denoted in lower case letters: 
\[ y_w = \frac{y_w}{Y}, \quad y_f = \frac{y_f}{Y}, \quad y_c = \frac{y_c}{Y} \].

Then macroeconomic equilibrium requires that investment equals savings:

\[ (g + \delta)K = Y - c_w Y_w \]  
\[ \Rightarrow (g + \delta)K = aK - c_w Y_w \]
\[ \Rightarrow y_w = \frac{a - g - \delta}{ac_w} \]  

Thus the workers' share in national income is determined by parameters independent of the central fund. Moreover it is clear from equation (7) that, for viability, we require:

\[ a \geq g + \delta \]  

In most proposals actually advanced the contribution fraction (a) would increase linearly over the first few (T) years of the fund's life to a maximum (a*). It will be assumed throughout this paper that all redemptions occur after the (minimum) redemption period of T years. Thus it is not until time T + \( \bar{T} \) that contributions and redemptions are based on the same fraction (see fig. 1). Throughout this paper, periods in excess of T + \( \bar{T} \) will be referred to as the "long-run". (Note that in the Danish 1973 proposal \( \bar{T} = 10, \ a^* = 5\%, \ T = 7 \)).
3: Equilibrium Paths

An equilibrium path is one along which the factor price frontier equation (equation (4)) and the macroeconomic equilibrium condition (equation (6)) are simultaneously satisfied. With a fund operating in the economy, equation (6) becomes

$$(g + \delta)K = Y - c_w(W + R - B) \quad (9)$$

(where $R =$ redemption income $B =$ fund contributions).

Let $\alpha(t) =$ contribution fraction, then on the assumptions of section 2, equation (9) gives:

$$(g + \delta)K(t) = Y(t) - c_w(1 - \alpha(t))w(t)L(t) + R(t)) \quad (10)$$

The problem then is to derive an expression for $R(t)$. Obviously for $t < T$, $R(t) = 0$. On the assumptions of section 2 (for $t \geq T$) $R(t)$ is the contribution made to the fund at time $t-T$, fully accumulated at the going rate of profit, defined net of the rate of depreciation. That is to say, for $t \geq T$,

$$R(t) = \alpha(t-T) w(t-T)L(t-T) e^{-\delta T} e^{A(t)} \quad (11)$$

where $A(t) = \int_{t-T}^{t} r(s)ds \quad (12)$

Equation (11) gives

$$R(t) = \alpha(t-T) w(t-T)L(t) e^{-(g+\delta)T} e^{A(t)} \quad (13)$$
since the labour force is growing exponentially at a rate \( g \). Using the factor price frontier (4) and substituting (13) into (10) we obtain:

\[
(g + \delta)K(t) = Y(t) - c_w((1 - \alpha(t))(a - r(t)))\rho L(t) + \\
\alpha(t-T)(a-r(t-T))\rho L(t) e^{-(g+\delta)T} e^A(t)
\]  

(14)

Dividing through by \( L(t) \) and using the production function (equation (2)), this gives:

\[
(g + \delta) = a - c_w((a-r(t))(1 - \alpha(t)) + \\
\alpha(t-T)(a-r(t-T)) e^{-(g+\delta)T} e^A(t)
\]  

(15)

Equation (15) gives a general equation for solution paths in \( r(t) \) (and hence in \( w(t) \), via the factor price frontier). Unfortunately, it is impossible to solve because of the presence of the term in \( e^A(t) \) on the R.H.S. It is possible however to establish a sufficient condition under which a constant price path exists in the long run. In the long run \( (t \geq T + \bar{T}) \) contribution and redemption fractions are equal and constant over time:

\[
\alpha(t) = \alpha(t-T) = \alpha \text{ for all } t \geq T + \bar{T}
\]  

(16)

A constant price path is one along which both wage rate and profit rate are constant over time:

\[
r(t) = r, w(t) = w = (a-r)\rho \text{ for all } t \geq T + \bar{T}
\]  

(17)
Substituting (16) and (17) into the general expression (15) we obtain:

\[ g + \delta = a - (a - r) C_w (1 - \alpha + \alpha e^{(r - \delta - g)T}) \]  

(18)

To find sufficient conditions for (18) to have a solution, define \( \Phi(r) \) by:

\[ \Phi(r) = g + \delta - a + (a - r) C_w (1 - \alpha + \alpha e^{(r - \delta - g)T}) \]  

(19)

Clearly \( \Phi \) is continuous in \( r \) and moreover:

\[ \Phi(a) = g + \delta - a < 0 \]  

(20)

from (8). Note also that \( 0 \leq r \leq a \), from (5).

Then if \( \Phi(0) > 0 \), the equation \( \Phi(r) = 0 \) must have a solution \( (0 \leq r \leq a) \). We have from (19):

\[ \Phi(0) = g + \delta - a + a C_w (1 - \alpha + \alpha e^{-(\delta + g)T}) \]  

(21)

Thus a sufficient condition for \( \Phi(0) > 0 \) and hence for the existence of a constant price path is

\[ g + \delta + C_w (1 - \alpha) - 1)a > 0 \]  

(22)

Various long run properties of constant price paths are discussed in George (1985a) and will not be duplicated here. A major purpose of the present paper is to deal with the short run \( (t \leq T + \bar{T}) \) when both contribution and redemption fractions are varying (see figure 1). In this case, in
general, constant price paths do not exist and recourse must be made to simulation methods in order to deal with the equilibrium condition (equation (15)). These methods and the simulation results are described in the following sections. The simulated paths exhibit, in the long run, heavily damped oscillations around the corresponding constant price paths defined by equation (18). All the qualitative results of George (1985a), which relate to constant price paths, re-appear for the simulated paths.

4: Simulation

Simulations were carried out using a very simple Fortran programme. First the model must be re-expressed in discrete time form. Let:

\[ R(t) = \text{redemption income paid at the beginning of year } t \]
\[ K_f(t) = \text{fund capital at beginning of year } t \text{ net of } R(t) \]

Hence:

\[ R(t) = 0 \quad t \leq T \]
\[ R(t) = (1+\gamma(t-1)-\delta)(1+r(t-2)-\delta)...(1+r(t-T)-\delta) \]
\[ \alpha(t-T)w(t-T)L(t-T) \quad t > T \quad (23) \]

For each time period the programme solves for equilibrium \( w(t) \) using an equation similar to (9) and then calculates \( r(t) \) from the factor price frontier (equation (4)). It then calculates redemption payments for the next time period \( R(t+1) \) from which it can obtain the income of the fund in year \( t \). At each stage the fund's share in the capital stock \( (K_f(t)/K(t)) \) is printed out along with the wage and profit rates and the
contribution fraction. Using the fund's income in period $t$, the programme calculates $\left(K_{(t+1)} \right)$, increases $K$, $L$ and $Y$ by the exogenous growth rate ($g$) and then repeats the whole process over again. This continues for 99 periods. The contribution function rises by an amount $\tilde{a}$ for each of the first $\tilde{T}$ years and then remains constant at $\tilde{a}.\tilde{T}$. The structure of the programme is set out in Figure 2.

Figure 2 near here.

Some of the parameter values were kept constant for all the simulation runs. They were:

- $g = 3\%$
- $c_w = 0.95$
- $a = 0.3$
- $b = 50.0$
- $\tilde{T} = 10$

The other parameters were varied between runs as follows:

- $T = 7, 10, 15$
- $\bar{a} = 0.5\%, 1.0\%$ (giving maximum contribution fractions of 5% and 10%)
- $\delta = 2\%, 4\%$

Thus twelve runs are reported altogether all of which satisfy the sufficient condition (equation (22)) for the existence of a constant price path in the long run. Note that
$T = 7, \bar{\alpha} = 0.5\%$ corresponds to the Danish 1973 proposal. The results of this run (for $\delta = 2\%$) are depicted in figure 3 and, qualitatively, are typical of all the runs. The fund's share in the capital stock peaks at or just after time $T + \bar{T}$ and then declines gradually to its long run value. The profit rate falls to a minimum at time $\bar{T}$, then rises and exhibits heavily damped oscillates about its long run value. The (pre-tax) wage rate is simply determined via the factor price frontier and consequently always moves in the opposite direction to the profit rate. The (pre-tax) wage rate rises in the first $\bar{T}$ years as the contribution tax rate rises, showing that the burden of this tax is initially shifted to profits, though by time $T + \bar{T}$ the burden is shifted back to wages. The workers' share in income of course remains constant with changes in (after-tax) wage income being matched by opposite changes in redemption income.

Tables 1 and 2 show maxima, minima, and long-run values for four key economic variables, the contribution fraction ($\alpha$), the fund's share in the total capital stock ($k_F$), the profit rate ($r$) and the wage rate ($w$). The runs in table 1 have $\delta = 2\%$ while those of table 2 have $\delta = 4\%$. It is clear that high depreciation rates effect the fund adversely, slightly lowering its share in the capital stock (cet. par.). Both tables depict substantially lower fund
shares than were suggested in Danish Government calculations (Danish Government 1973). These suggest that after eight years the fund's share would be 10% and after 15 years, 35%. The first runs in tables 1 and 2 correspond to the parameter values of the Danish 1973 proposal. They indicate maximum fund-shares of 7.48% and 6.89% respectively and long run fund shares of 6.53% and 5.91% respectively.

Tables 1, 2 near here

It is clear from both tables that raising the contribution fraction and lengthening the redemption period increases the fund-share, both maximum and long-run. This is consistent with the analysis of constant price paths in George (1985a). A redemption period of 15 years and a maximum contribution fraction of 10% gives values of $k_F$ closer to Danish official estimates. In this case $k_F$ reaches 7.12% after eight years and 22.21% after ten years; it peaks at 32.64% after 34 years and declines to a long-run value of 31.77%

5: Conclusion

The impact of a wage-earners' investment fund on the economy will depend crucially on how large a share of the capital stock it controls. The results of the simulation analysis reported here suggest fund-shares substantially lower than those indicated in official estimates. The fund shares can be increased by lengthening the redemption period or raising the contribution fraction. Both measures,
particularly the latter, would sharply reduce the real profit rate in the short run, which may present problems of its own. Increasing the redemption period would possibly be resisted by the trade unions. In Denmark they originally wanted a five year rather than a seven year redemption period, though the present Swedish arrangements allow redemptions only in the form of pensions.

The possibility of the fund taking over the entire capital stock is a remote one. Indeed, governments would have to contemplate substantially higher contribution fractions and longer redemption periods than has hitherto been the case if a wage-earners' investment fund is to achieve a share in the capital stock substantially greater than that of a medium-sized private pension fund.
FOOTNOTES

1. An earlier version of this paper was given at seminars at L.S.E. and the European University Institute, Florence, Italy. I am grateful for the constructive comments made at those seminars. I would particularly acknowledge the helpful advice and comments of Saul Estrin, Stanislaw Gomulka, Mario Nuti and Will Bartlett. The usual disclaimer applies.

2. In interpreting results from George (1985a) in terms of the present paper, the natural growth rate $n$ in the former paper must be replaced by the growth rate gross of depreciation, $g + \delta$. 
Fraction determining fund contributions

Fraction determining fund redemptions

Figure 1
Set parameters and initial values

\[ t > 99? \]

Yes \( \rightarrow \) Stop

No \( \rightarrow \) \( t = t + 1 \)

No \( \rightarrow \) \( a = \dot{a}, t \)

Yes \( \rightarrow \) \( a = \ddot{a}, t \)

\[ w(t) = (y(t) - (g + \delta)) K(t) - c_w R(t)/c_w (1 - a(t)L(t)) \]

\[ r(t) = a - w(t)/b \]

\[ t < T? \]

Yes \( \rightarrow \) \( R(t+1) = 0 \)

No \( \rightarrow \) \( R(t+1) = \alpha(t-T+1) w(t-T+1) L(t-T+1) (1+r(t)-\delta) + \ldots + \alpha(t)(1+r(t+1)-\delta) \)

\[ k_F(t) = K_F(t)/K(t) \]

\[ Y_F(t) = a(t) w(t) L(t) - R(t+1) + r(t) K_F(t) \]

Print out variables of interest

\[ K_F(t+1) = (1 - \delta) K_F(t) + Y_F(t) \]

\[ K(t+1) = (1+g) K(t), L(t+1) = (1+g) L(t), Y(t+1) = a K(t+1) \]

Fig. 2: Flow Diagram for the Simulation Programme
Figure 3  Simulation Run for the Danish (1973) proposal

\( T = 7, \quad \bar{\alpha} = 0.5\%, \quad \delta = 2\% \)
<table>
<thead>
<tr>
<th>$T$</th>
<th>$\alpha$ (%)</th>
<th>$k_f$ (%)</th>
<th>$r$ (%)</th>
<th>$w$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>0.5%</td>
<td>Max 5</td>
<td>7.48</td>
<td>3.56</td>
</tr>
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<td></td>
<td>2%</td>
<td>Min 0</td>
<td>0.0</td>
<td>2.66</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LR 5</td>
<td>6.53</td>
<td>3.56</td>
</tr>
<tr>
<td>7</td>
<td>1.0%</td>
<td>Max 10</td>
<td>15.25</td>
<td>3.42</td>
</tr>
<tr>
<td></td>
<td>2%</td>
<td>Min 0</td>
<td>0.0</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LR 10</td>
<td>13.41</td>
<td>3.41</td>
</tr>
<tr>
<td>10</td>
<td>0.5%</td>
<td>Max 5</td>
<td>10.96</td>
<td>3.55</td>
</tr>
<tr>
<td></td>
<td>2%</td>
<td>Min 0</td>
<td>0.0</td>
<td>2.30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LR 5</td>
<td>10.14</td>
<td>3.50</td>
</tr>
<tr>
<td>10</td>
<td>1.0%</td>
<td>Max 10</td>
<td>22.20</td>
<td>3.42</td>
</tr>
<tr>
<td></td>
<td>2%</td>
<td>Min 0</td>
<td>0.0</td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LR 10</td>
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<td>3.27</td>
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<tr>
<td>15</td>
<td>0.5%</td>
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<td></td>
<td>2%</td>
<td>Min 0</td>
<td>0.0</td>
<td>0.76</td>
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<td></td>
<td></td>
<td>LR 10</td>
<td>31.77</td>
<td>2.99</td>
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Table 1: Summary of simulation runs for $\delta = 2\%$
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<thead>
<tr>
<th>T = 7, $\alpha = 0.5%$</th>
<th>$\delta = 4%$</th>
<th>$\alpha (%)$</th>
<th>$k_f (%)$</th>
<th>$r (%)$</th>
<th>$w$</th>
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<td>Max</td>
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<td>6.89</td>
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<td>5.68</td>
<td>40.53</td>
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<table>
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<tr>
<th>T = 7, $\alpha = 1.0%$</th>
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<th>$k_f (%)$</th>
<th>$r (%)$</th>
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<th>$k_f (%)$</th>
<th>$r (%)$</th>
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<td>3.10</td>
<td>40.76</td>
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<td>5.44</td>
<td>40.93</td>
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<th>$\delta = 4%$</th>
<th>$\alpha (%)$</th>
<th>$k_f (%)$</th>
<th>$r (%)$</th>
<th>$w$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max</td>
<td>5</td>
<td>15.17</td>
<td>5.67</td>
<td>42.47</td>
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<tr>
<td>Min</td>
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<td>0.0</td>
<td>4.52</td>
<td>40.55</td>
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<tr>
<td>LR</td>
<td>5</td>
<td>14.51</td>
<td>5.56</td>
<td>40.74</td>
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<th>T = 15, $\alpha = 1.0%$</th>
<th>$\delta = 4%$</th>
<th>$\alpha (%)$</th>
<th>$k_f (%)$</th>
<th>$r (%)$</th>
<th>$w$</th>
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<td>5.54</td>
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<td>3.10</td>
<td>40.76</td>
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<tr>
<td>LR</td>
<td>10</td>
<td>29.32</td>
<td>5.22</td>
<td>41.30</td>
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Table 2: Summary of simulation runs for $\delta = 4\%$
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