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## Stochastic simulations of a macroeconomic disequilibrium model for West Germany

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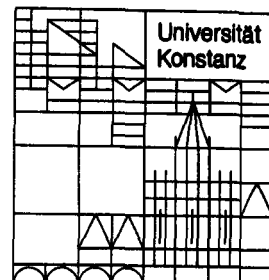
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Diskussionsbeiträge



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wissenschaften und Statistik

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**Stochastic Simulations of a  
Macroeconomic Disequilibrium Model  
for West Germany**

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Disequilibrium Model for West Germany\***

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## Abstract

In this paper a macroeconometric disequilibrium model for West Germany is presented and its quality for policy simulations and forecasting are analyzed using stochastic in-sample simulations. The model is built on a dynamic disequilibrium model of firms' behaviour. Due to delayed adjustment of production inputs, and sluggish adjustment of wages and prices, a market disequilibrium can arise on labour and goods micro markets. Aggregation leads to an explicit functional form for aggregate transactions on labour and goods markets dependent on aggregate supply, demand, and mismatch.

The empirical application of the model confirms that underutilization of labour and capital are important phenomena. Shares of firms facing different constraints on the goods and labour market can be derived from the model. These proportions changed considerably during the last three decades. Some deterministic simulations of different shocks affecting the economy including fiscal and monetary shocks, and migratory movements showed a strong influence of the prevailing rationing regime on the outcomes.

The robustness of these results is assessed using stochastic in-sample simulations for the period 1981–1988. Simulations using stochastic errors for the model's 23 estimated equations help to evaluate the effects of non-linearities and dynamic features on the forecasting quality of the model. Furthermore, a comparison between deterministic and different stochastic simulations allows the conclusion to be drawn that notwithstanding the non-linearities and dynamic features the simulation properties of the model are reasonable in general.

# 1 Introduction

This paper presents the macroeconometric disequilibrium model for West Germany developed in Konstanz during the last five years.<sup>1</sup> The model is built on a dynamic model of firms' behaviour. Due to delayed adjustment of employment, investment, and the production technology, and sluggish adjustment of wages and prices with respect to disequilibrium situations, a market disequilibrium can arise on labour and goods micro markets. The firms take into account both prevailing and expected disequilibrium situations while deciding about optimal production, employment, investment and production technology. By an aggregation procedure introduced by Lambert (1988), explicit functionals for aggregate transactions on labour and goods markets dependent on aggregate supply, aggregate demand, and a mismatch parameter can be derived from the model at the firm level.

The empirical application of the model confirms that both underutilization of labour and capital are important phenomena. As an important feature, shares of firms facing different constraints on the goods and labour market can be derived from the model. The estimates of the model show that these proportions changed considerably during the last three decades. Some deterministic simulations of different shocks affecting the economy including fiscal and monetary shocks, and migratory movements showed a strong influence of the prevailing rationing regime on the outcomes.

In order to assess the robustness of these results and to analyze the effects of non-linearities and dynamic adjustment processes in the model we perform stochastic simulations. The results presented in this paper might be regarded as a first step in doing so for two reasons. Firstly, due to restrictions by available time and computing resources the stochastics of the simulations were restricted to the error terms in the estimated equations, in particular we do not consider yet the influence of errors in the estimation of the regression parameters. Secondly, it must be stressed that the version of the Konstanz' disequilibrium model used for the analysis presented in this paper is neither the latest already developed nor the final one.

In fact, during the last few months the model has been extended to a link-model of Germany and the four major trading partners within the EC (modeled as one aggregate). The feedback to policy measures in one country by the others is included, where the reaction of the trading partners

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<sup>1</sup>We will shortly refer to the different versions of this model as the Konstanz' disequilibrium model. Some references are given in section 2.

is not assumed to be exogenous any more.<sup>2</sup> Further extensions were made with regard to a dynamic modeling of the employment function. We did not use this version of the model for our first stochastic simulations, since it contains about twice as many independent variables and an even more complex dynamic structure. However, the methods developed and tested for the smaller version will be applied to the larger model in the near future.

The version of the model we use in this paper is restricted to the West German economy and is based on the estimation period 1960–1988. By performing stochastic in-sample simulations of the error terms both for the actual values of the exogenous variables and for a fiscal shock in 1981–1983 its simulation properties and the effect of non-linearities and dynamic adjustment processes are analysed.

The paper is organised as follows. In the next section the basic philosophy of the disequilibrium model is outlined and the central upshot of the estimation, the regime proportions are presented. In the first subsection of section 3 we take a short glance at some issues in simulating models, different simulation methods and sources of errors in models are discussed especially. The following subsection is devoted to an overview of the deterministic (policy) simulations which have been performed using different versions of the Konstanz' disequilibrium model during the last few years. The main part of section 3 and of the paper as a whole presents the results of stochastic (policy) simulations performed with the model version presented in section 2. We conclude with some remarks on the necessity and advantages of using stochastic simulations and the implications of the results achieved for further modelling.

## 2 The Disequilibrium Model

Unemployment became of increasing importance for Germany during the 1980s for the second time after the great depression. As the level of the unemployment rate remained very high throughout the eighties during an ongoing boom period the question naturally arised as to the reasons for this development. Why did the markets not react in a way suitable to reduce unemployment? Obviously, a missing or too slow adjustment of wages and prices and/or of transacted quantities was one of the major reasons. There exists a huge literature on the microeconomics of rigid wages and prices or a sluggish adjustment of transacted quantities. Quoted reasons range

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<sup>2</sup>See Heidbrink (1994).

from institutional rigidities over adjustment costs to theories stressing the importance of asymmetric information, for example, in the efficiency wage hypothesis.<sup>3</sup> Whatever the reasons might be, whenever wages and prices or quantities are not adjusting or not adjusting fast enough to clear markets at any instant of time, some form of rationing can be observed.

In order to allow for such situations of rationing or disequilibrium in econometric models three different approaches or generations of models must be distinguished. We try to sketch the basic differences between these three generations using the labour market as an example. The models of the first generation were characterized by the assumption that observed employment is equal to the minimum of aggregate labour supply and demand.<sup>4</sup> Consequently, the whole economy is either rationed on the supply or on the demand side. Therefore, these models cannot explain the observation of unemployment and vacancies at the same time.

The second generation of disequilibrium models tried to reduce the discontinuity of regime transitions of the first generation models by introducing time varying regression coefficients which might be estimated by the Kalman-filter-methodology.<sup>5</sup> However, it might be difficult to give an economic explanation of the estimated changes in parameters.

Switching from an aggregate point of view to the observations of micro markets we obtain the third generation models. Here, the traditional minimum condition is imposed solely on micro markets, i.e. on markets with one homogenous good or homogenous labour. Then, some of the markets might be supply side constrained whereas others are constrained by missing demand. Consequently, these models allow for simultaneous unemployment and vacancies on the aggregate labour market. The share of micro markets in different regimes evolves during the cycle in a continuous way, as the number of micro markets is assumed to be infinite. Using an explicit aggregation procedure of these micro markets aggregate equations for transactions on the labour market can be derived.

In the following subsection we give some more details on the third generation model we use for our stochastic simulation experiment without attempting to do so exhaustively as this has been done elsewhere.<sup>6</sup>

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<sup>3</sup>An overview of the literature on the microeconomics of wage formation can be found in Franz (1991).

<sup>4</sup>Cf. Quandt (1988).

<sup>5</sup>Cf. Möller (1988).

<sup>6</sup>See for example Franz, Heidbrink and Scheremet (1992), Franz, Oser and Winker (1993), Franz and Smolny (1990), and the monograph by Smolny (1993) and the literature cited



## 2.1 The Basic Framework

The macroeconomic model is based on the assumption that firms decide about output and employment in three stages. These stages exist due to the different flexibility of the adjustment of different production inputs.

*In the short run* the firm's supply of output is fixed and the transacted quantities on the (micro) market ( $YT$ ) are the minimum of the goods demanded ( $YD$ ) and goods supplied ( $YS$ ), i.e.

$$YT = \min(YD, YS). \quad (1)$$

*In the medium run* employment can be adjusted, whereas the capital stock is still predetermined. Then, employment ( $LT$ ) is the minimum of labour demand ( $LD$ ) and labour supply ( $LS$ ), i.e.,

$$LT = \min(LD, LS). \quad (2)$$

The demand for labour is either determined by expected goods demand or by existing capacities. Employment determined by existing capacities ( $LYC$ ) is given by definition as

$$LYC \equiv \frac{YC}{\pi_L^*} \equiv K \cdot \frac{\pi_K^*}{\pi_L^*}, \quad (3)$$

where  $\pi_L^*$  and  $\pi_K^*$  denote optimal capital and labour productivity, respectively. They can be derived from the first-order conditions of a cost minimizing firm given a CES-type production technology and depend on factor price ratios and efficiency terms reflecting labour and capital saving technical progress, respectively.

The determination of demand determined employment ( $LYD$ ) is best understood by recognizing that in the optimum marginal costs of labour (i.e., the wage rate  $W$ ) should be equal to marginal returns from labour, i.e.

$$W = P \cdot \text{prob} \left[ YD > \frac{LYD}{\pi_L^*} \right] \cdot \pi_L^*, \quad (4)$$

where  $P$  is the price of goods. The second expression on the right hand side stands for the probability that expected goods demand  $YD$  exceeds those quantities which can be produced with optimal employment ( $LYD$ ).

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therein.

Consequently, optimal labour demand depends on expected goods demand, optimal labour productivity, the uncertainty of expected goods demand as given by its logarithmic variance and the income share of labour at the optimal labour productivity.

*In the long run* firms can adjust capacities ( $YC$ ) by changing the capital stock ( $K$ ) and/or the production technology.  $YC$  is determined by the condition that the expected marginal return of capital should equal capital costs. Capacities are chosen to be proportional to the expected minimum of goods demand  $YD$  and goods supply. Further determinants are a measure of profitability and the variance of the expected minimum.

We now turn to the aggregation of demand and supply quantities from the micro goods and labour markets to economy wide quantities. It can be shown that in a reasonable economic framework the distribution of demand and supply on the micro markets follows a bivariate log-normal distribution.<sup>7</sup> Following Lambert (1988), aggregate transactions can then be approximated by a CES-type function of aggregated demand and supply (“smoothing by aggregation”). For output we obtain

$$YT = \{(LT \cdot \pi_L)^{-\rho_G} + YD^{-\rho_G}\}^{-\frac{1}{\rho_G}}, \quad (5)$$

where supply is employment times labour productivity at full utilization of labour.  $YD$  represents aggregate goods demand. It is modeled by private consumption, investment, exports and imports as endogenous variables, and government expenditures and housing investment as exogenous variables.<sup>8</sup> Consumption depends in the usual way on disposable income, the interest rate, and on a labour market indicator. Based on the firm’s optimal capital stock decision aggregate investment is determined by expected goods demand, the share of capital and labour, and a time trend as proxy for technical progress.

The possibility of rationing is introduced in the following way. Excess demand for domestic goods will lead to additional imports to bypass the constraint, while on the other hand, excess demand on the world market will restrain German imports. The opposite may hold for exports: Domestic constraints will hinder foreign demand, while supply constraints on the

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<sup>7</sup>For a derivation of this result see Smolny (1993). Smolny also shows that the strict assumption of log-normality is not essential for the derivation of the following approximations.

<sup>8</sup>The public sector including government expenditures will be endogenized in future versions of the model.

foreign market may induce additional German exports. Rationing of the demand components other than exports and imports will be observed only in the case of simultaneous constraints on the domestic and the world markets. No significance of those effects was found. Therefore they may be regarded as rather small. Demand for exports ( $XD$ ) and imports ( $MD$ ) are calculated for a situation with no rationing on the domestic market. This gives the following identity for goods demand

$$YD = C + I + G + XD - MD. \quad (6)$$

The mismatch parameter  $\rho_G$  entering the CES-function of aggregate output (5) measures the mismatch of supply and demand on the goods markets. The main determinant of mismatch on the goods market is the expectation error of demand on the micro markets. As firms have no perfect information about demand at the time of the employment decision, they have to decide under uncertainty. Employment determines output. Therefore, the size of the mismatch on the goods market  $\rho_G$  depends essentially on the adjustment speed of employment with respect to changing conditions on the goods market. For  $\rho_G$  approaching infinity equation (5) tends to the usual minimum-condition. In this limiting case not only each micro market but also the aggregate economy is subject to only one of the constraints.

Similar arguments can be applied to the labour market. Employment is determined either by labour supply  $LS$  or by labour demand  $LD$ . The latter is split into labour demand based on expected goods demand ( $LYD$ ) and labour demand brought about by productive capacities ( $LYC$ ). By the same way of reasoning as for the output equation we obtain<sup>9</sup>

$$LT = \left\{ LS^{-\rho_{LT}} + (LYD)^{-\rho_{LT}} + (LYC)^{-\rho_{LT}} \right\}^{-\frac{1}{\rho_{LT}}}. \quad (7)$$

The mismatch parameter  $\rho_{LT}$  represents what is mostly understood by the term mismatch on the labour market such as regional or qualification mismatch.

Equation (7) can be transformed into elasticities of  $LT$  with respect to  $LS$ ,  $LYD$ , and  $LYC$ . These elasticities represent the share of firms ("regimes") being constrained either by labour supply ( $\pi_S$ ), expected goods demand

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<sup>9</sup>This CES-function could be interpreted as well as a matching function in the framework of Blanchard, Diamond (1989). For a discussion of this aspect see Franz, Smolny (1993).

( $\pi_D$ ), or capacities ( $\pi_C$ )

$$\left. \begin{aligned} \pi_S &= \frac{\partial LT/LT}{\partial LS/LS} = \left\{ LT/LS \right\}^{\rho_{LT}} \\ \pi_D &= \frac{\partial LT/LT}{\partial L_{YD}/L_{YD}} = \left\{ LT/(L_{YD}) \right\}^{\rho_{LT}} \\ \pi_C &= \frac{\partial LT/LT}{\partial L_{YC}/L_{YC}} = \left\{ LT/L_{YC} \right\}^{\rho_{LT}} \end{aligned} \right\} \quad (8)$$

Wages and prices are determined by demand and supply factors and react slowly to market disequilibria. Price setting of firms is assumed to follow a mark-up pricing on several types of costs, where the mark-up depends on demand conditions on the goods market. Costs considered are wage costs, i.e., standard wages relative to actual labour productivity, prices of imported goods relative to the GNP-deflator, value added taxes, and the share of non-wage labour costs in total labour costs. Wages are set in negotiations between labour unions and employers. Explanatory factors are expected inflation, change in labour productivity, and several supply variables. The effect of labour market conditions is captured by the unemployment rate.

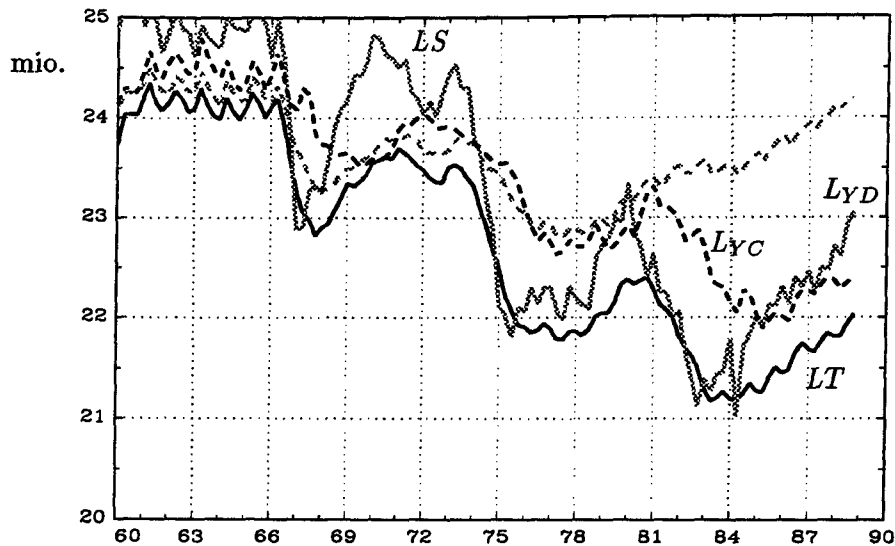
## 2.2 Some Estimation Results

The upshot of the estimation results of this model can be summarized by figure 2 which displays the regime proportions of the labour market for the estimation period 1960 to 1988 (quarterly data).<sup>10</sup> Before turning to a short description of these results it should be noted that, as the regime proportions are restricted to sum up to 100 percent, they show the reasons for disequilibrium situations but cannot be used to assess the quantitative importance of rationing on goods and labour markets. In order to do the latter one has to look at the employment series  $LS$ ,  $L_{YD}$  and  $L_{YC}$  giving rise to these regime shares.

In fact, the employment series in figure 1 show that until 1966 and after the mild recession in 1966/67 up to 1973 the labour market was characterized by a near to equilibrium situation. The still existing impediments were mainly due to a slight labour supply shortage. The importance of the labour supply constraints is mirrored by the immigration policy towards non-EC-foreigners. In order to close the gap on the German labour market recruitment agreements were signed between Germany and Greece, former

<sup>10</sup> A broader discussion of estimation equations and estimation results for an advanced version of the model can be found in Smolny (1993).

Figure 1: Employment Series (seasonal adjusted)<sup>a)</sup>



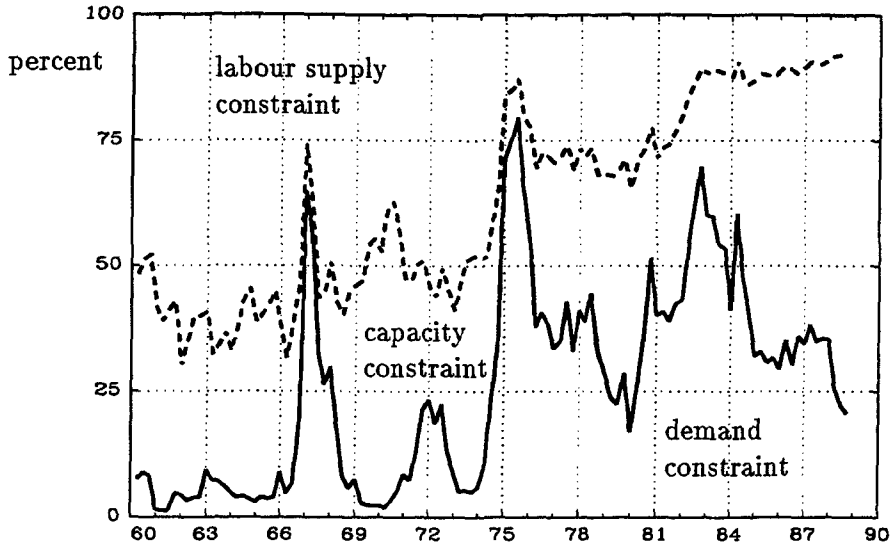
a) See text for details.

Yugoslavia, Portugal, Spain, Turkey and several North African states. During the mild recession in 1967 the resulting inflow of foreign workers was reduced by one half, and with the immigration stop enacted in 1973 all recruitment offices were closed and the recruitment of non-EC workers on the firms' own initiative was restricted severely.<sup>11</sup>

Thus, the first oil price shock in 1973 hit the German economy in a boom period. A restrictive monetary policy by the Deutsche Bundesbank facing the effects of the enormous wage push in 1970 and the breakdown of the Bretton-Woods exchange rate system reduced investment and consumption demand even further. Consequently, the goods demand constraints became binding resulting in an increase of unemployment exceeding one million. The partial recovery of the economy after the first OPEC shock was terminated with the second oil price shock again accompanied by a restrictive monetary policy. After 1984 with the ongoing boom period an increasing importance

<sup>11</sup>Cf. Franz, Oser and Winker (1994).

Figure 2: Regime Proportions (Labour Market)<sup>a)</sup>



a) See text for details.

of capacity constraints can be observed, as the increasing rate of capacity utilization did not lead to the necessary enlargement of productive capacities. This non-response might be an answer to the restrictive monetary and fiscal policies pursued at the beginning of the eighties. However, this question can only be answered with the final version of the model including the public and monetary sectors.

### 3 Simulations

In this section methods and results of simulation studies of the disequilibrium model are discussed. We start with a short description of different simulation techniques. In subsection 3.2 the central topics and some results of previous simulations using the Konstanz' disequilibrium model are presented. Since all these simulations were deterministic, we first add results of stochastic simulations and then assess the issue of robustness of the re-

sults achieved with deterministic simulations on the base of these simulation results in subsection 3.3.

### 3.1 Simulation Methods

The macroeconomic disequilibrium model introduced in the previous section can be formally given as

$$y_{i,t} = F_{i,t}(y_{1,t}, \dots, y_{i-1,t}, y_{i+1,t}, \dots, y_{n,t}, x_t, \beta, \varepsilon_{i,t}), \quad (9)$$

$$i = 1, \dots, n, \quad t = 1, \dots, T,$$

where  $y_t \equiv (y_{1,t}, \dots, y_{n,t})$  is the vector of dimension  $n$  of endogenous variables,  $x_t$  the vector of predetermined variables including lagged endogenous variables as they appear in the model equations,  $\beta$  the coefficient vector, and  $\varepsilon_t \equiv (\varepsilon_{1,t}, \dots, \varepsilon_{m,t}, 0, \dots, 0)$  the vector of errors at time  $t$ , where, without loss of generality, it has been assumed that the first  $m$  equations of the system are stochastic,<sup>12</sup> whereas the remaining equations are deterministic, i.e. with  $\varepsilon_{i,t}$  identically zero for  $i > m$  and all  $t$ . These deterministic equations are definitory equalities or equalities derived from national accounts identities. Finally,  $F_{i,t}$  describes the functional form of the equations. As in our model this functional form is assumed to remain unchanged over time,<sup>13</sup> we use the notation  $F_i$  in the sequel.

It should be noted that due to the non-linear specification of the transacted quantities on goods and labour markets some of the functions  $F_i$  are far from being linear.

The results of the estimation of the model give one solution to equation (9). For any change in the exogenous variables  $x_t$ , the coefficient vector  $\beta$  or the additive error terms  $\varepsilon_t$ , which becomes necessary for different kinds of simulation experiments or forecasts, a new solution to (9) has to be calculated. Due to the interdependent structure of the model numerical methods have to be used for this purpose. Most software packages allowing simulation of econometric models use the Gauss-Seidel algorithm to solve these equations.<sup>14</sup> Given values for  $x_t$ ,  $\beta$  and  $\varepsilon_t$  this generalized linear iteration method can be used to solve for the endogenous variables  $y_t$ . At least for

<sup>12</sup>The version of the Konstanz' disequilibrium model used in this paper contains 23 stochastic equations.

<sup>13</sup>Seasonal effects or changes in variable definitions etc. are taken into account by including dummy variables.

<sup>14</sup>Cf. Ortega and Rheinboldt (1970), pp. 214ff, Quandt (1983), pp. 724-727, and Fisher and Hughes Hallett (1988).

small scale econometric models this algorithm works quite well in practice, although no guarantee for convergence can be given.<sup>15</sup>

Following the exposition in Fair (1986), p. 1981, several kinds of simulations can be distinguished. A first important distinction for dynamic models is the one between a *static simulation* using the actual values for lagged endogenous variables and a *dynamic simulation* using the predicted values from the solution of the previous period for these lagged observations. As the disequilibrium model analyzed in this paper stresses the aspect of dynamic adjustment in prices and quantities, it seems to be more appropriate to use the second concept for our simulations.

Another important difference exists between *ex post simulation* using the observed values of the exogenous variables and *ex ante simulation* using assumptions or otherwise predicted values for the exogenous variables. As the estimation of the model was performed for a sample from 1960 to 1988, and as the data set includes predicted values for the exogenous variables up to 1995 on an information set available at the end of 1992, we would have the possibility to perform both kinds of simulations. However, as our interest is concentrated in identifying problems in the model structure and the assumptions about the error terms, we concentrate in this paper on ex post simulations.

In general, a further distinction can be made between *in-sample simulation* and *out-of-sample simulation*. For the first, the simulation period lies in the estimation sample, whereas for the second it lies outside. Consequently, for our application the presented simulations for the period 1981 to 1988 are in-sample and ex post simulations, whereas simulations for the period 1989 to 1992 would be out-of-sample and ex post simulations, and finally simulations for the period 1993 to 1995 would be out-of-sample and ex ante simulations. The results of a deterministic simulation in Franz, Heidebrink and Smolny (1993) show that the dynamic modelling of investment and employment adjustment leads to problems in meeting the evolution of these variables in an ex post out-of-sample simulation of the post reunification period. Therefore, as we do not aim to assess the impact of a "cosmic shock"<sup>16</sup> such as reunification on our model we restrict the simulation period to end in 1988.

If only one set of values of the error terms is used, the simulation is

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<sup>15</sup>For large scale models a reordering of the equation might help to improve performance and achieve convergence. Cf. Gilli and Pauletto (1993).

<sup>16</sup>Cf. Siebert (1993).



said to be *deterministic*. In general, the expected values of error terms are zero, and therefore they are set to zero for most deterministic simulations. The basic advantage of deterministic simulations is the easy implementation in most econometric software packages and the low computational burden they impose. However, there are at least three restrictions of deterministic simulations which might be overcome by the use of stochastic simulation methods discussed in the sequel:

1. For non-linear and/or dynamic models the solution values of the endogenous variables in most cases are not equal to the mathematical expectation of these variables.
2. It is not possible to present statistics on the distribution of the simulated endogenous variables such as standard deviations or confidence intervals.
3. Using the standard method of deterministic simulation by setting all error terms to zero does not allow for observed covariances and/or autocorrelations between the error terms and over time.

One central aim of the simulation study presented in this paper is to assess the importance of these problems by comparison of results achieved with deterministic and stochastic simulations.

In order to introduce *stochastic* simulation methods and to give reasons for the choice of methods we use, we have to give a short overview on the stochastics and other possible sources of errors of the model as presented in equation (9). Using the classification of Pindyck and Rubinfeld (1991), p. 393, four different sources of errors can be distinguished:

1. The additive error term  $\varepsilon_t$  of the stochastic part of the model.
2. The difference between true and estimated values for the model's parameters  $\beta$ .
3. Errors in the exogenous variables.
4. Misspecification of the functional form of individual equations or of the dynamic structure of the model as a whole including assumptions about the joint distribution of additive errors and parameters.

The estimation of the model allows some conclusions to be drawn about the (joint) distribution of the additive error terms  $\varepsilon_t$  and the parameter

estimates  $\beta$ . Hence, a *stochastic* simulation of the effects of the first two possible sources of errors mentioned in the above list is straightforward. It is performed by drawing many<sup>17</sup> sets of error terms and/or coefficient estimates out of their estimated or assumed distribution. To perform a joint stochastic simulation of additive error terms and errors in the coefficient estimates  $\beta$  two approaches are proposed in the literature. Fair (1980) proposed to draw first a set of random coefficients from the distribution of  $\beta$  and using these parameters to perform a stochastic simulation on the additive error terms  $\varepsilon_t$ . This procedure has to be repeated many times resulting in a heavy computational burden. Therefore, Hall (1986) proposed to perform drawings of  $\beta$  and  $\varepsilon_t$  at the same time avoiding the “inner loop”. Of course, this results in a large reduction in computational costs. However, in order to use Hall’s method one has to assume that the errors in  $\beta$  and the additive error terms are independent. Furthermore, in order to use one of these techniques one has to presume that the errors are completely characterized by their estimated covariance matrices. Otherwise, covariances between different kinds of errors might exist as well as autocorrelation.

The assessment of the effects of errors in exogenous variables becomes especially important for *ex ante* simulations when the exogenous variables have to be forecasted themselves for a forecast of the model. Another reason for the analysis of errors in exogenous variables is given by the continuous revisions of national account data. Stochastic simulations could be used to estimate these effects if some assumptions about the distribution of the errors can be made.

The last mentioned possible source of errors, misspecification of the functional form or the dynamic structure of the model is even more difficult to judge, as standard estimation techniques in general do not reveal much information about these errors. Nevertheless, there exist possibilities to use stochastic simulation techniques to measure the impact of a change in the functional form or the dynamic structure of the model. The main difference to the other possible sources of errors discussed above is that in this case the drawings are not performed out of distributions of values for  $\varepsilon_t$ ,  $\beta$  or  $x_t$ , respectively, but out of a predetermined class of functional forms  $F_t$ . Although this seems to be feasible, it is very demanding as a distribution of functional forms has to be assumed. Furthermore, it would require enormous computing resources. This might be the reasons for the fact that – to our knowledge – there exist no stochastic simulations with regard to these

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<sup>17</sup>For our study we use 1.000 error sets for each simulation.

possible sources of errors.

As we restricted the analysis in this paper to ex post in-sample simulations we do not consider errors in exogenous variables, nor do we try to implement stochastic simulation techniques of functional form or dynamic structure. However, the outcome of the stochastic simulations might help to detect misspecification of the model which could be overcome in future versions.

Due to restrictions of computing resources and available time we focus on the additive error terms. Consequently, the results presented in subsection 3.3 are based solely on stochastic simulations of these error terms assuming that they are fully characterized by their covariance matrix and a joint normal distribution. A stochastic specification of the coefficient vector  $\beta$  and a relaxation of the distributional assumptions is left for future work.<sup>18</sup>

Before turning to the results of the stochastic simulations, the following subsection sketches some deterministic policy simulations performed with different versions of the Konstanz' disequilibrium model in order to give an overview of the kind of questions which might be inquired in this framework.

### 3.2 Deterministic Policy Simulations

Various kinds of policy simulations have already been performed with different versions of the Konstanz' disequilibrium model. A common feature of all these simulations is that they were performed as deterministic simulations, i.e. with all error terms set either to zero or to their estimated values. The simulations differed in the time span under consideration including in-sample and out-of-sample simulations, whether ex post or ex ante simulations were performed, and, finally, in the kind of shocks analyzed.

We shall not try to give a complete summary of all these simulations, but merely try to give an overview on the shocks analyzed and an upshot of the results.

In Franz, Heidbrink und Scheremet (1992) one of the earlier versions of the Konstanz' disequilibrium model was presented. The authors simulate the model in the period 63.1 to 88.4 in order to evaluate its dynamic properties. The simulation reveals high correlations between actual and simulated values for trended variables like output, imports, and exports, whereas the non-trended variables do not perform as well. In particular, prices, interest rates

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<sup>18</sup>Instead of assuming a particular parameterized distribution of  $\epsilon$  and/or  $\beta$  one could use non-parametric resampling methods such as bootstrapping.

was performed for the period 1990 to 1995 in order to assess the forecasting abilities of the model. Up to 1992 this was done using already observed values for the exogenous variables, whereas for the period 1993 to 1995 ex ante simulations were necessary. The forecasts generated by this simulation are not very close to the observed values. However, they do not exceed the forecast errors generated by other models. In fact, German unification might be regarded as a “cosmic shock” very difficult to forecast in its economic consequences.

In order to assess the influence of German unification on the West German economy a hypothetical situation was assumed and the model simulated. The assumptions concerned the real net exports from West to East Germany, the labour supply due to emigrants from East Germany and commuters, tax increases due to unification and the real interest rate. All these variables were held at their level assumed for the case of no unification. In short, the simulation experiment mirrors the outcome of a Keynesian expenditure program on a great scale. Without unification the recession in West Germany would have started about two years earlier than it actually did.

In his analysis of the link-model for Germany and an EC-aggregate Heidbrink (1994) performs deterministic in-sample simulations for the sample period 75.2 to 89.3 to assess the quality of the estimated equations. In this version of the model, he finds the largest deviations for aggregate employment and the interest rate for the period 1982 to 1984.

In addition to these simulations the effects of changes in exogenous variables or the introduction of some policy measures are simulated using in-sample ex post deterministic simulations and analyzing the differences of the values of important endogenous variables with and without the assumed policy measure. The assumptions on exogenous variables refer to the growth rates in other OECD countries and to the exchange rate of the US-\$ to the German Mark and other EC-currencies. Furthermore, coordinated and uncoordinated monetary and fiscal policy measures are analyzed.

### **3.3 Stochastic Simulations of the Disequilibrium Model**

As pointed out at the end of subsection 3.1 the stochastics of our simulations of the Konstanz' disequilibrium model are restricted to the additive error terms due to limits by time and available computer resources. In developing and estimating the model presented in section 2 it has been assumed that the equations (and hence the error terms, too) are independent and therefore could be estimated separately. During the estimation the different equations

of the model have been tested for auto-correlation of the error terms and so we will neglect the possible remaining auto-correlation for the simulation of the final version of the estimated model.<sup>21</sup> As usual the error terms are assumed to follow a normal distribution. To check whether the assumption of contemporary independent error terms, i.e. a diagonal covariance matrix, is reasonable or if the model should be reestimated simultaneously we used two different methods to generate the error terms for the simulations: independent errors and errors following a normal distribution with the estimated covariance structure of the residuals.

In a first attempt we created error terms which followed the kind of distribution assumed during the estimation of the different parts of the model, i.e. the covariance matrix was assumed to have non-zero entries only on the diagonal, these entries being the estimated variances of the corresponding additive error terms  $\varepsilon_{i,t}$  over the time period 1980 to 1988. As we used only the estimated error terms for the last decade of the estimation period we had to adjust the drawn error terms by the (very small) mean  $\mu$  of the estimated residuals over this period.

The model is implemented in Micro TSP 7.0 and the error terms of the first run were also generated using the built-in random number generator of this software package by multiplying draws from the standard-normal distribution with the respective standard deviations. The model was solved 1000 times for the time period from 1981.2 to 1995.3.<sup>22</sup> As we do not focus on the out-of-sample forecast quality of the model in this paper, we restrict the presentation of results to the in-sample period 1981 to 1988.

The second attempt dropped the assumption of contemporary independent error terms. Instead, the error terms were assumed to follow a joint normal distribution  $\mathcal{N}(\mu, \Sigma)$  with  $\Sigma$  being the covariance matrix of the estimated error terms during the time period 1980 to 1988.<sup>23</sup> The generation of the error terms for the simulation at one point in time was done by premultiplying a  $m \times 1$  vector of drawings from the standard-normal distribution by a matrix  $P$ , this matrix  $P$  being the lower triangular matrix of a Cholesky

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<sup>21</sup>The methods for stochastic simulations introduced in subsection 3.1 do allow use of any kind of error structure, in particular bootstrapping methods could be used to draw the error terms of the common intra- and inter-temporal empirical distribution of the residuals. C.f. Fitzenberger (1993).

<sup>22</sup>For the period 1988.4 to 1995.3 which falls out of the estimation sample the realized and forecasted values for the exogeneous variables are the same as used in Franz, Oser and Winker (1994).

<sup>23</sup>It should be noted that  $\Sigma$  could be estimated in the usual way as the number of 36 quarterly observations exceeded the number of 23 stochastic equations.

and the utilization rates of labour and capital show lower correlation.

The experience of increasing labour supply due to the immigration of so called "guest workers" in the sixties and seventies until the immigration stop enacted in 1973, the migration of ethnic Germans from Eastern Europe in the eighties and, finally, the migration from East to West Germany after 1989 raised the question as to the consequences of an increased or reduced migration flow. In Franz and Smolny (1990) and Smolny (1992) these effects are simulated using estimated migration equations for the six major countries of origin of the guest workers. The in-sample simulations in these papers show that the effect of a reduced migration flow depends heavily on the prevailing regimes on goods and labour markets. As long as a large number of firms is constrained by available labour supply a reduction of migration leads to stronger rationing and to output losses, whereas in a regime of capital shortage reduced immigration flows result in a decrease in the unemployment rate.

The simulation study in Franz, Oser and Winker (1994) is mainly interested in the (expected) effects of the immigration after 1989 due to the changing conditions in Eastern Europe and East Germany.<sup>19</sup> They use a version of the disequilibrium model very close to the one presented in the previous section. In order to assess the effects of migration after 1989 an out-of-sample and – with regard to the time span 1993–1995 ex ante – simulation had to be performed. The baseline solution obtained using expected values of the exogenous variables<sup>20</sup> in general shows reasonable behaviour. However, the wage and price equations exhibited a rather unstable behaviour. As in the earlier studies on migration a strong dependence of the effects on the prevailing regime proportions were found. A strong reduction of migration from 1989 onwards would have resulted in an increasing proportion of firms being rationed by available labour supply. Until the capacities could adapt to this situation a loss in GNP growth rates would have been the consequence for at least two years. However, due to the fact that labour supply shortage was hardly binding at the end of the eighties the effects on employment would have been rather small.

Franz, Heidbrink and Smolny (1993) present another simulation study of the effects of German unification using the disequilibrium model. The aim of this paper is twofold. Firstly, an out-of-sample deterministic simulation

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<sup>19</sup> A more detailed presentation of the simulation study and the central results can be found in Franz, Oser and Winker (1993).

<sup>20</sup> The expectations were formed using the information available up to the fourth quarter of 1992.

decomposition<sup>24</sup> of the covariance matrix  $\Sigma$ , i.e.

$$P P' = \Sigma . \quad (10)$$

The computation of  $\Sigma$ ,  $P$  and the error terms was performed using GAUSS 3.1. Again the model was solved 1000 times for the time period from 1981.2 to 1995.3 using the Gauss–Seidl algorithm implemented in Micro TSP 7.0.

If the results of the two simulations differ substantially using independently generated errors for the first run and errors generated according to the estimated covariance matrix for the second run, this will be a strong indication that the different parts of the model are *not independent*. Furthermore, the results might give hints about which parts of the model should be reestimated simultaneously.

To obtain a quantitative comparison of the results of our two attempts we used different measures to judge the accuracy and the stability of our simulation results. The first measure is the root mean squared error (*RMSE*).<sup>25</sup> The *RMSE* for the endogenous variable  $i$  is defined by

$$RMSE = \sqrt{\frac{1}{T} \sum_{t=1}^T (\hat{y}_{it} - \bar{y}_{it})^2}, \quad (11)$$

where  $\bar{y}_{it}$  denotes the (mean) forecast and  $\hat{y}_{it}$  the actual value of the endogenous variable  $i$  for period  $t$ . It might be considered as a measure for the accuracy of the forecasts, or mean values of simulations, respectively.

A different approach consists of comparing the variance or the standard deviations of the forecasts. This can be done by calculating the mean of the variances or standard deviations for some endogenous variable  $i$  over the simulation period  $t = 1, \dots, T$ . Then, the average variance measure (*AVAR*) can be defined by

$$AVAR = \frac{1}{T} \sum_{t=1}^T \text{var}(y_{it}), \quad (12)$$

where  $\text{var}(y_{it})$  denotes the variance of the simulated values for variable  $i$  in time period  $t$ . Analogously the average standard deviations measure

<sup>24</sup>Cf. Ripley (1987), p. 98.

<sup>25</sup>Cf. Fair (1986). The *RMSE* can only be computed for the (in-sample) period 1981.2 to 1988.4 as its calculation is based on deviations from realized values of the endogenous variables.

(*ASTD*) is given by

$$ASTD = \frac{1}{T} \sum_{t=1}^T \sqrt{\text{var}(y_{it})}. \quad (13)$$

In contrast to the *RMSE*, the *AVAR* and *ASTD* measures can be used both for in-sample and out-of-sample simulations. Furthermore, the *ASTD* in connection with the sample mean has an intuitive meaning as it gives a range in which “most” of the simulated values might be expected to fall. However, as both *AVAR* and *ASTD* are based on the distribution of simulated values they can only be applied to stochastic simulations.

*AVAR* and *ASTD* both depend heavily on the variance of the error terms entered into the respective stochastic equation. To get more information on the impact of non-linearities and the links between system equations a fourth measure “standardizes” the *ASTD* with the standard deviation  $\sigma_i$  of the error terms in the respective stochastic equation. The standardized average standard deviation measure

$$SASTD = ASTD / \sigma_i \quad (14)$$

then gives us the factor by which the standard deviation of the simulated endogenous variable  $i$  is larger than the standard deviation of its respective error term. In the simplest case of one linear equation *SASTD* should equal one. Hence, a factor larger than one indicates a worsening of the simulation quality due to non-linearities, dynamics and spill-over from other stochastic equations.

Table 1 shows the mean, *RMSE*, *ASTD* and *SASTD* for some major endogenous macroeconomic variables of the model. It presents the results for independent error terms and error terms following a joint distribution as discussed above as well as results for the deterministic simulation in which all error terms were set to zero. We also show the actual mean of the variables.

Looking at table 1 almost no difference in the predictive quality can be detected between the simulations using correlated and uncorrelated error terms, respectively. The results are almost the same for both stochastic simulations<sup>26</sup> and therefore the assumption of independent equations (and error terms) which allowed for the separate estimation of the models’ equations cannot be rejected on the base of these measures. The mean values of the stochastic simulations do not seem to be more accurate than a deterministic simulation with the error terms set to zero. But stochastic simulations provide further valuable information about error bounds and allow

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<sup>26</sup>This is true for the other endogenous variables, too.



Table 1: Measures of Forecasting Performance 1981-1988

Variable	Errors	Mean	<i>RMSE</i>	<i>ASTD</i>	<i>SASTD</i>
output (bio. DM)	indep.	347.36	4.493	6.062	4.633
	correl.	347.28	4.451	5.945	4.619
	zero	348.48	5.225	—	—
	actual	345.24	—	—	—
employment (mio.)	indep.	21.695	0.362	0.403	4.015
	correl.	21.698	0.361	0.382	3.871
	zero	21.601	0.332	—	—
	actual	21.589	—	—	—
inflation rate (percent)	indep.	2.468	0.951	0.923	0.687
	correl.	2.480	0.931	1.037	0.785
	zero	2.620	0.877	—	—
	actual	2.759	—	—	—
growth rate of nominal wages (percent)	indep.	4.091	1.239	1.396	1.137
	correl.	4.098	1.252	1.452	1.203
	zero	4.339	1.167	—	—
	actual	4.380	—	—	—
growth rate of real wages (percent)	indep.	1.624	1.008	1.130	0.757
	correl.	1.617	1.017	1.025	0.689
	zero	1.720	1.032	—	—
	actual	1.621	—	—	—
investment rate (percent)	indep.	2.833	0.114	0.022	4.112
	correl.	2.835	0.107	0.022	4.238
	zero	2.858	0.112	—	—
	actual	2.796	—	—	—

calculation of confidence intervals. The *RMSEs* are relatively small for real variables like employment and output but quite large for wages and prices (seen in relation to the respective mean). Prices and wages also show a large dispersion in our simulation experiments. The simulated error terms have a strong influence on the outcome of these variables which indicates that these equations might be improved in future versions of the model.

Our last measure *SASTD* indicates a strong impact of non-linearities in the equation for aggregate output, employment and investment, whereas the dispersion in the wage and price equations seems to be damped by spill-over effects.

A more thorough analysis of the figures of some major endogenous variables presented in the sequel might give further insights. Figure 3 shows seasonal adjusted<sup>27</sup> values of actual real output (without public sector) as the grey shaded line together with the mean of the stochastic simulation using uncorrelated error terms as solid and the 5%– and 95%–percentiles as dashed lines. As the corresponding values for the simulation using correlated error terms cannot be distinguished visually they are omitted from the figure.

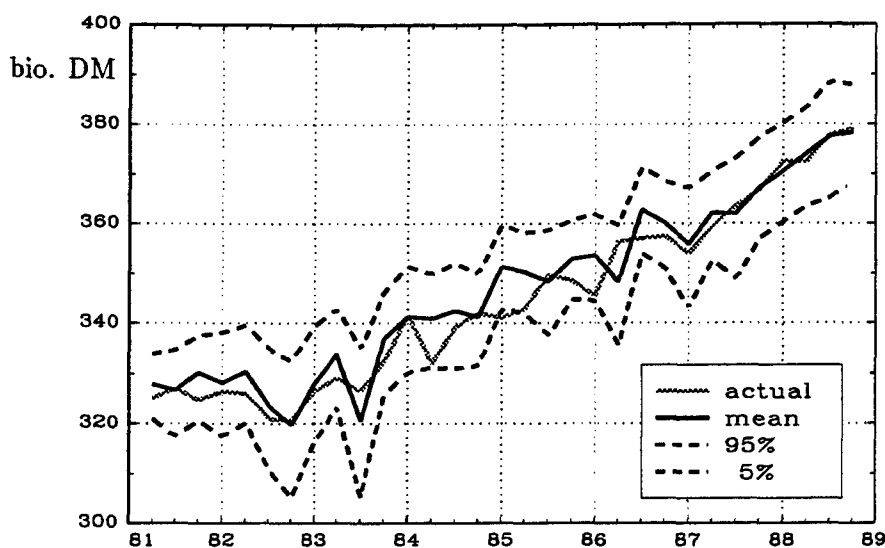
The plot exhibits that the actual values of real output nearly always falls within the symmetric 90%–confidence interval formed by the 5%– and 95%–percentiles. The interpretation of this fact is that the results of the stochastic simulation do not differ significantly from the actual values. However, the simulation mean does not behave exactly the same way as the actual data in the short run. Especially for the period 1984–1986 larger deviations of the short term dynamics can be detected. Nevertheless, the overall impression of figure 3 – and the same holds true for other real variables such as employment – is a satisfying fit of the real part of the model.

As standard deviations or confidence intervals tell only part of the story about the distribution of the endogenous variables we had a closer look using figure 4. This figure plots the distributions of  $y_{it} - \bar{y}_{it}$  for  $y_i$  being the real output as above and  $t$  covering the simulation period from 1981 to 1988. The tails of these distributions in general are rather flat though with some outliers for example in 1982 and 1983. Furthermore, it might be stated that the dispersion is slightly increasing over time probably due to the growing importance of dynamic effects which are absent at the very beginning of the simulation period as the actual values are used for the lagged endogenous

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<sup>27</sup>The seasonal adjustment was performed using the seasonal factors of the actual data for all plotted series.

Figure 3: Real Output<sup>a)</sup> (without public sector, seasonal adjusted)<sup>b)</sup>



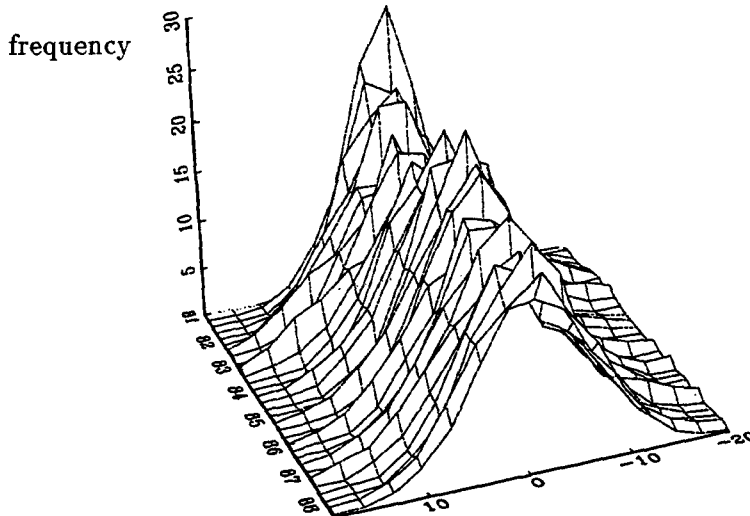
a) In prices of 1980.

b) See text for details.

variables. Still the overall impression indicates that the distributions are not too pathological. Thus, the assumption of independent normally distributed errors cannot be rejected on the basis of these results for the real quantities of the model.

Let us now turn to the equations determining the development of wages and prices. Confirming our a priori assumptions which were based on the outcomes of the deterministic simulations quoted in subsection 3.2 this part of the model proved to be less stable. Figure 5 may summarize some central features plotting the actual growth rate of real wages together with the mean and 5%- and 95%-percentiles of the stochastic simulation using independent error terms. Again, the differences between the two stochastic simulations performed proved to be too small to be distinguished visually. Although the model contains the growth rates of prices and nominal wages as quarterly figures we prefer to present the annual growth rates which are not concealed by the strong seasonal pattern of nominal wages.

Figure 4: Distribution of Simulated Real Output<sup>a)</sup>

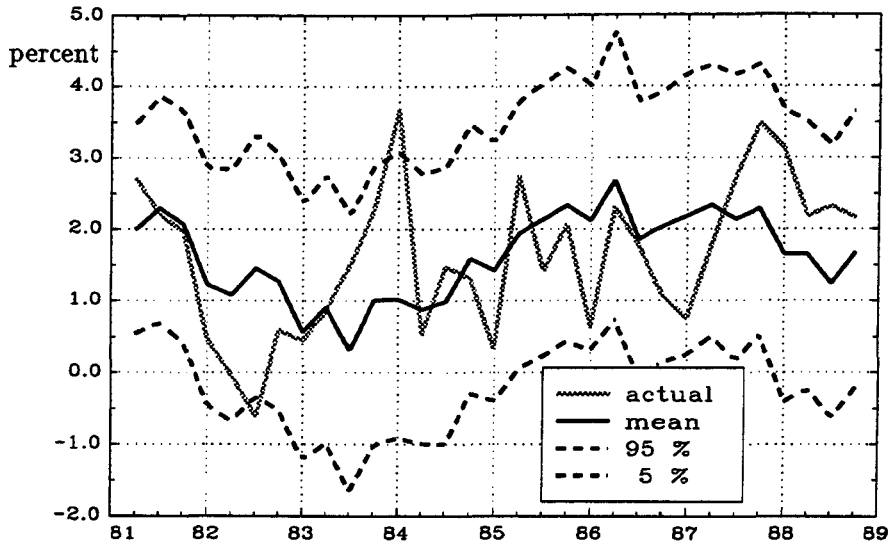


a) See text for details.

While the actual values of the real wage annual growth rate still fit into the 10%–confidence interval most of the time, the short term deviations between actual value and mean value of the simulation are distinct. The dynamic modelling of wages and prices seemingly introduces a slower adjustment of real wages than could be observed during the 1980's. Looking at the figures for the inflation rate and the annual growth rate of nominal wages, which are not presented here, most of the short term deviations seems to stem from the wage equation.

As one aim of this paper is to assess the quality of policy simulations based on the Konstanz' disequilibrium model we now turn to the results of the simulation of a fiscal shock as discussed in Heidbrink (1994), pp. 226ff. While Heidbrink compares the outcomes of coordinated and uncoordinated fiscal policies in West Germany and an EC-aggregate we concentrate on West Germany. As Heidbrink we assume a real increase in public expenditures for the period 1981 – 1983 totaling 40 bio. DM to face the decrease of employment after 1981. The shock starts with 3 bio. DM in 1981.1, in-

Figure 5: Growth Rate of Real Wages<sup>a)</sup>



a) See text for details.

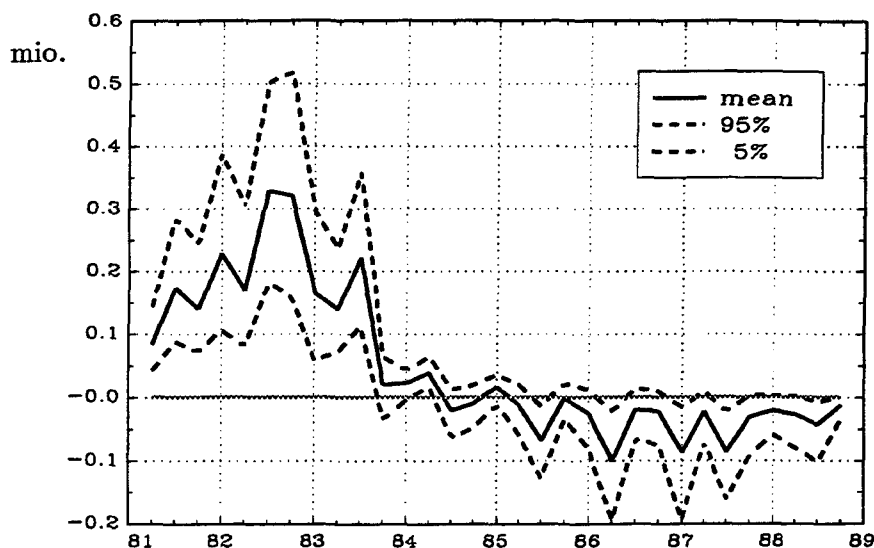
creases to 5 bio. DM in 1981.4, remains at this level up to 1982.4, and then decreases to 1 bio. DM in 1983.4.

In order to obtain the figures presented in the sequel two stochastic simulations had to be performed, one with the actual public expenditures and one with the increased values. For every drawing of additive error terms the difference of the endogenous variables for these two simulations was calculated. It should be noted that the stochastic additive error term in the equations cancels out. Hence, the sole remaining source of dispersion is to be found in the non-linear equations of the model.

Figure 6 shows the effect on employment of the Keynesian expenditure program defined by the fiscal shock. It shows the mean and the 5%- and 95%-percentiles of the 1.000 replications using uncorrelated error terms.

As expected, the fiscal shock lead to a marked and significant increase of employment during the shock period 1981 - 1983, whereas afterwards the level of employment falls short of its level without the fiscal shock. Using the error bounds obtained from the stochastic simulations it can be stated

Figure 6: Employment<sup>a)</sup> (Differences due to Fiscal Shock)<sup>b)</sup>



a) Without public sector.

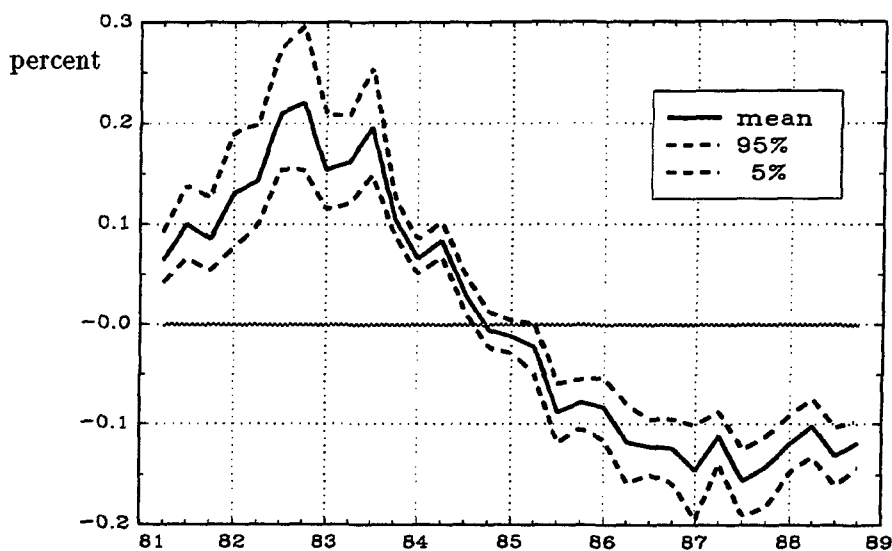
b) See text for details.

that the temporary increase of employment exceeds 100.000 persons from 1982.1 to 1983.2 at the 5%-level, whereas the negative effect after 1984.2 is hardly significant at the 5%-level.

While the error bounds are quite large for the simulated employment differences, figure 7 presents much smaller bounds for the simulated differences of the quarterly inflation rate. As the dispersion depends only on the non-linearities of the model, this result is not too surprising because the CES-function for employment is highly non-linear whereas the price equation is a linear one. Keeping in mind the quite different outcome of the level simulations presented above two conclusions can be drawn. Firstly, the non-satisfactory behaviour of wage and price equations is not critical for policy simulations if the model's uncertainty is restricted to the additive error terms. Secondly, errors in the parameter estimates should be included in further stochastic simulations to take account of all the uncertainty not only in the wage and price equations.

Figure 7 shows a marked and significant increase in the quarterly inflation rate during and one year after the fiscal shock. However, this increase due to the demand shock in 1981 to 1983 is mirrored in lower inflation rates from 1985 on. The increased demand during the shock period leads to higher investment rates up to 1984.4. Consequently, in the sequel the capacity constraint is less binding resulting in the lower inflation rate from 1985 on, while the inverse is true during the shock phase.

Figure 7: Quarterly Inflation Rate (Differences due to Fiscal Shock)<sup>a)</sup>



a) See text for details.

## 4 Conclusion

The results presented in this paper show that at least in a highly non-linear and dynamic framework like the Konstanz' disequilibrium model stochastic simulations provide valuable information. Although the means of our stochastic simulations did not differ substantially from the results of a deterministic simulation, the stochastic simulations allow calculation of error

bounds and confidence intervals. Consequently, the robustness of the outcome of policy simulations can be assessed. Furthermore, it becomes possible to judge the quality of estimated equations or parts of the model with regard to their simulation properties.

Although our results should be considered only as a first step towards an analysis of the Konstanz' disequilibrium model using stochastic simulation methods we might conclude yet that the real part of the model is quite robust whereas wages and prices exhibit larger dispersion in a framework of stochastic errors.

The next step of our analysis will include the stochastics of the estimated coefficients. Simulating the model with partly deterministic and stochastic errors and coefficients will allow identification of the sources of the rather weak performance of the estimated wage and price equations and give hints for their improvement. One reason for the weak performance might be the fact that the public and financial sector is not yet completely included in the model. Consequently, further work on the model will be concentrated on obtaining a closed model for policy simulations by including the public and the financial sector.

After an updating of the data and the estimated equations for the post reunification period, it will become possible to perform policy simulations of the effects of reunification including the effects on and via public debt. The stochastic simulations performed on a prior version of the model in this paper then will help to improve its dynamic structure and to detect possible sources of misspecification. Furthermore, it will be possible to present confidence regions for the estimated effects of simulated policy measures.

## References

- [1] O. J. Blanchard and P. Diamond. *The Beveridge Curve*. *Brooking Papers on Economic Activity* 1 (1989), 1–76.
- [2] R. C. Fair. *Estimating the Uncertainty of Policy Effects in Nonlinear Models*. *Econometrica* 48,6 (1980), 1381–1391.
- [3] R. C. Fair. *Evaluating the Predictive Accuracy of Models*. In: Z. Griliches and M. D. Intriligator (eds). *Handbook of Econometrics, Vol. III*. Elsevier Science Publishers, Amsterdam 1986.
- [4] P. G. Fisher and A. J. Hughes Hallett. *Iterative Techniques for Solving Simultaneous Equation Systems: A View form the Economics Litera-*



- ture. *Journal of Computational and Applied Mathematics* 24 (1988), 241–255.
- [5] B. Fitzenberger. *The Moving Block Bootstrap and Robust Inference in Linear Regressions*. CEPR Technical Paper No. 340, Stanford University, Stanford 1993.
- [6] W. Franz. *Arbeitsmarktökonomik*. Springer, Berlin/Heidelberg/New York 1991.
- [7] W. Franz, G. W. Heidbrink, and W. Scheremet. *International Trade in a Disequilibrium Model*. In: H. J. Vosgerau (ed.). *European Integration in the World Market*. Springer, Berlin 1992, 513–561.
- [8] W. Franz, G. W. Heidbrink, and W. Smolny. *The Impact of German Unification on West Germany's Goods and Labor Market: A Macroeconometric Disequilibrium Model in Action*. Discussionpaper No. 7, Center for International Labor Economic, University of Konstanz, Konstanz 1993.
- [9] W. Franz, U. Oser, and P. Winker. *Migratory Movements in a Disequilibrium Macroeconometric Model for West Germany*. Discussionpaper No. 202, SFB 178, University of Konstanz, Konstanz 1993.
- [10] W. Franz, U. Oser, and P. Winker. *A macroeconometric disequilibrium analysis of current and future migration from Eastern Europe into West Germany*. *Journal of Population Economics* 7 (1994), 217–234.
- [11] W. Franz and W. Smolny. *Internationale Migration und wirtschaftliche Entwicklung: Eine theoretische und empirische Analyse mit Hilfe eines Mengenrationierungsmodells*. In: B. Felderer (ed.). *Bevölkerung und Wirtschaft*. Duncker & Humblot, Berlin 1990, 195–209.
- [12] W. Franz and W. Smolny. *The Measurement and Interpretation of Vacancy Data and the Dynamics of the Beveridge-Curve: The German Case*. Discussionpaper No. 3, Center for International Labor Economic, University of Konstanz, Konstanz 1993.
- [13] M. Gilli and G. Pauletto. *Econometric Model Simulation on Parallel Computers*. *The International Journal of Supercomputer Applications* 7,3 (1993), 254–264.

- [14] S. G. Hall. *Estimating the Uncertainty of the Simulation Properties of Large Nonlinear Econometric Models*. Applied Economics 18 (1986), 985–993.
- [15] G. Heidbrink. *Wirtschaftspolitik in einem makroökonomischen Ungleichgewichtsmodell*. Dissertation, Universität Konstanz, Konstanz 1994.
- [16] J.–P. Lambert. *Disequilibrium Macroeconomic Models*. Cambridge University Press, Cambridge 1988.
- [17] J. Möller. *Time-varying coefficients in a simultaneous equation model: theoretical concept and some simulation results*. Discussionpaper No. 241, University of Konstanz, Konstanz 1988.
- [18] J. M. Ortega and W. C. Rheinboldt. *Iterative Solution of Nonlinear Equations in Several Variables*. Academic Press, New York 1970.
- [19] R. S. Pindyck and D. L. Rubinfeld. *Econometric Models and Economic Forecasts*. McGraw–Hill, New York 1991 (3rd Edition).
- [20] R. E. Quandt. *Computational Problems and Methods*. In: Z. Griliches and M. D. Intriligator (eds.). *Handbook of Econometrics, Vol. I*. North-Holland, Amsterdam 1983.
- [21] R. E. Quandt. *The Econometrics of Disequilibrium*. Basil Blackwell, New York 1988.
- [22] B. Ripley. *Stochastic Simulation*. John Wiley & Sons, New York 1987.
- [23] H. Siebert. *The Big Bang with the Big Brother*. Kieler Diskussionsbeiträge No. 211, Kiel 1993.
- [24] W. Smolny. *Macroeconomic Consequences of International Labour Migration. Simulation Experience from an Econometric Disequilibrium Model*. In: H.–J. Vosgerau (ed.). *European Integration in the World Economy*. Springer, Berlin 1992.
- [25] W. Smolny. *Dynamic factor demand in a rationing context. Theory and estimation of a macroeconomic model for the Federal Republic of Germany*. Physica, Heidelberg 1993.