MIMIC
An Applied General Equilibrium model for the Netherlands

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Abstract

MIMIC is CPB's applied general equilibrium model for the Dutch economy. The model is designed to help Dutch policymakers investigate the structural labor-market implications of changes in the systems of taxation and social insurance. MIMIC combines a rich theoretical framework based on modern economic theories, a firm empirical foundation, and an elaborate description of the actual tax and social insurance systems in the Netherlands. The theoretical foundation of the model implies that one can interpret the model results rather easily in terms of rational microeconomic behavior, despite the disaggregated nature of the model and its rich institutional detail. This institutional detail makes the model especially relevant for policymaking.

Samenvatting

Het toegepast algemeen evenwichtsmodel MIMIC is ontwikkeld om beleidsmakers te adviseren over de structurele gevolgen voor de arbeidsmarkt van maatregelen in de sfeer van belastingen en sociale zekerheid. Het model heeft een sterke micro-theoretische onderbouwing, waardoor de modeluitkomsten goed kunnen worden geïnterpreteerd in termen van micro-economische gedragsreacties. Verder heeft MIMIC een grondige empirische basis en kent het model een gedetailleerde beschrijving van de Nederlandse stelsels van belastingen en sociale zekerheid. Dit laatste maakt het model geschikt voor het doorrekenen van specifieke beleidsmaatregelen.

Introduction

This paper discusses the MIcro Macro model to analyze the Institutional Context (MIMIC). MIMIC originated in 1987, when Dutch policymakers were discussing several, sometimes detailed, policy proposals aimed at raising employment and reducing unemployment. CPB models were unable at that time to properly analyze the economic impact of these proposals. For example, CPB's macro-econometric model was unable to explore specific changes in the tax structure, as the model contained only one tax

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variable. MIMIC was supposed to fill this gap. Another push-factor for the development of MIMIC was the breakdown in the belief in macroeconometric models, especially due to the Lucas critique.

MIMIC is not subject to the Lucas critique. Indeed, as an applied general equilibrium model, it draws on microeconomic theory to derive supply and demand from optimizing behavior by decentralized agents. In modeling the labor market, the model departs from the traditional assumption of market clearing that is found in most applied general equilibrium models. In modeling various labor-market imperfections that give rise to involuntary unemployment, MIMIC employs modern labor-market theories. In particular, it includes elements of wage bargaining, efficiency wages, and costly job matching. In this way, the model describes equilibrium unemployment in terms of the structure of the tax system, minimum wages, and the features of social insurance. See the box for a summary of the main characteristics of MIMIC.

Another distinctive feature of MIMIC is that it contains a disaggregated household model aimed at adequately describing the impact of the statutory rates of taxation and social security premiums on labor supply and the income distribution. In particular, the model accounts for heterogeneity in household composition, labor-market status, educational level, wages, and preferences for leisure. Incorporating this heterogeneity allows the model to explore the various trade-offs facing policymakers, including those between equity and efficiency. Especially the distinction between three skill types and between short-term- and long-term unemployment, makes the model appropriate to investigate targeted policy measures.

MIMIC has a firm empirical basis. Various crucial relationships in the model, including contractual wage formation and the production function, have been estimated from time series data. The elasticities in the wage equation are equal to the long-term elasticities in the JADE model (for a description of this model, see elsewhere in this issue of *CPB Report*). Furthermore, microeconometric estimates for the Netherlands have been used to calibrate the labor-supply model and the matching model. Moreover, income distributions have been calibrated by employing micro data. Finally, MIMIC pays close attention to the institutional details of the tax and social insurance systems.

In recent years, MIMIC has been extended in several directions (compared to an earlier version discussed in Gelauff and Graafland, 1994). Several theoretical extensions aim at more adequately modeling the effects of high marginal tax rates on the quality and quantity of labor supply in the formal sector. In particular, the model endogenized labor supply of breadwinners and single persons, as well as human capital accumulation. Furthermore, the informal economy, which consists of

Main characteristics of MIMIC

purpose	Analyzes the structural impact of changes in the systems of taxation and social insurance on the labor market.	
policy simulations	In-work benefits (targeted at the unskilled), negative income tax, earned income tax credit, marriage relief, unemployment and disability benefits, vouchers for long-term unemployed, minimum wages, child care subsidies.	
methodology	Applied general equilibrium model.	
time horizon	Long-term (= over ten years). MIMIC may generate a sequence of static equilibria.	
empirical foundation	Calibration for 1993. The model of the firm and wage formation are estimated on the basis of macro-economic time-series data. Parameters in the household model and the matching model are calibrated on the basis of microeconometric estimates derived from the literature. MIMIC contains institutional details of taxation and social insurance.	
number of variables	15,000 endogenous; 2,000 exogenous.	
disaggregation	Firms:	six production sectors and five factors of production;
	Households:	40 types of households with ten income classes for each type;
	Wage formation:	three skill types;
	Job matching:	three skill types; Short-term and long-term unemployment;
main mechanisms	Firms:	Price setting; Labor demand, including black labor; On-the-job training;
	Households:	Labor supply, including black labor and household production; Off-the-job training;
	Wage formation:	Collective wage bargaining per skill type; Incidental wage per skill type;
	Job matching:	Unemployed: endogenous search intensity and reservation wage; Firms Minimum productivity requirements;
international comparison	DREAM (Knudsen et. al., 1998)	

the black market and household production, was included in the model. The empirical foundation of the production function and contractual wage formation has been improved, while the model was calibrated on the basis of a more recent data set for 1993. Finally, to be able to explore specific policies targeted at combating long-term and unskilled unemployment, the new MIMIC model distinguishes between unskilled, low-skilled and high-skilled labor, as well as between short-term and long-run unemployment.[1]

Structure of the model

Broadly speaking, MIMIC is comprised of four submodels. These describe, respectively, firm behavior, household behavior, wage formation and the matching process between vacancies and unemployment.

The model of the firm
From the optimizing behavior of firms, we derive factor demands as a function of input prices, domestic and foreign output prices, and production. The demand elasticities for firms are based on Draper and Manders (1996), who find that the elasticity of substitution between labor and capital is small compared to that between unskilled, low-skilled and high-skilled labor.

Marginal labor costs affect firm behavior in three additional ways. First, for each skill type, firms can substitute formal labor for labor from the black market. Second, firms may pay their formally employed workers in a partly informal manner (i.e. without reporting a certain part to the tax authority). Finally, high marginal labor costs reduce the incentives for firms to invest in on-the-job training.

The household model
By maximizing utility subject to a time constraint and a budget constraint, households select labor supply from a limited set of discrete options on the labor market. For each of these options, total labor supply is subdivided between formal labor and black labor, depending on after-tax wage differentials between the formal and the informal labor market. The uncompensated labor-supply elasticity varies between 1 for partners and 0.1 for breadwinners.

Consumption consists of labor-intensive services and other goods. Labor-intensive services can be bought on both the formal market and the black market, depending on relative prices. The price of black labor follows from an equilibrium condition on the black labor market.

Households can be engaged in off-the-job training. In particular, through acquiring more skills, they can raise their productivity. High marginal tax rates discourage investments in human capital by reducing the return to training activities.

Wage formation
Wage formation per skill type is described by a wage-bargaining model. The corresponding wage equation is esti-

Figure 1 Main links in the MIMIC model
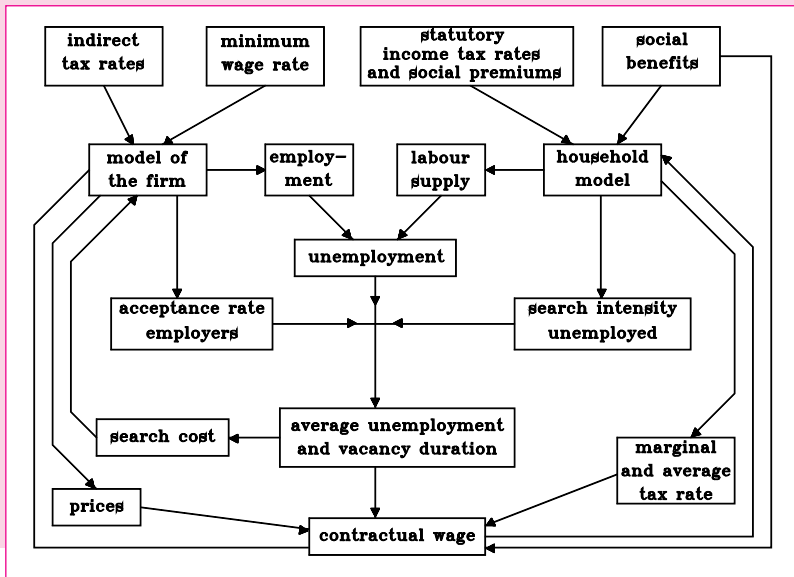
The public sector
Government behavior is largely exogenous in MIMIC. The model contains several public institutions, including the statutory income tax system in the Netherlands in 1998, VAT rates, "employers and employees" social security contributions, the official minimum wage, several social benefit schemes, and a number of policy instruments targeted at specific groups, such as the long-term unemployed or the unskilled.

The model as a whole
Figure 1 reviews the most important relations between institutions and the functioning of the labor market in MIMIC. In particular, it shows how changes in indirect taxes, minimum wages, income taxes and social benefits affect the equilibrium. To illustrate, an increase in indirect taxes raises the wage rate, thereby reducing labor demand. Higher minimum wages make employers more reluctant to attract (unskilled) labor, thereby raising average vacancy duration and reducing labor demand. Marginal income taxes are important determinants of labor-supply behavior. Taxes and replacement rates have important effects on wage formation, and thus for unemployment.

mated using Dutch time-series data (see Graafland and Huizinga, 1997). Gross wages are positively related to consumer prices, producer prices and the average tax and premium burden, with elasticities of 0.5, 0.5 and 0.6, respectively. A higher replacement rate – defined as the net unemployment benefit relative to the net wage rate – raises gross wages (since this improves the threat point of the union), thereby enhancing their bargaining power in wage negotiations. The elasticity of the replacement rate in the wage equation is around 0.3. Wages decrease with the unemployment rate with an elasticity of $\angle 2$. The marginal tax rate exerts a small negative influence on wages. This is because high marginal taxes make wage increases less attractive for unions – since a large part flows to the government, rather than to workers. The marginal-tax elasticity of $\angle 0.1$ for wages is much smaller in absolute value than the elasticity of the average tax. Hence, a simultaneous reduction in the marginal and average tax rates reduces the wage rate.

Job matching
Following Pissarides (1990), MIMIC incorporates a market for jobs per type of skill. On this market, unemployed people meet firms that search for appropriate employees to fill their vacancies. The search strategy of the unemployed is described by their search intensity and their reservation wage. A higher replacement rate lowers search intensity and raises the reservation wage, thereby exacerbating the mismatch on the labor market. This raises search costs, boosts incidental wages and raises unemployment. In light of the minimum wage, employers require a minimum productivity level from potential new employees. Indeed, since the unemployed are characterized by heterogenous productivity levels, the minimum wage constitutes a restriction in the matching process of unskilled and low-skilled workers.

Tax simulations with MIMIC
To illustrate the performance of MIMIC, we present four alternative cuts in income taxes: two different reductions in marginal tax rates and two different tax allowances. In all experiments, the ex-ante reduction in tax revenues equals 0.5% of GDP. The government budget is balanced through an equivalent reduction in government consumption. The experiments are revenue neutral ex-post. In particular, if tax revenues change in time, e.g. due to behavioral responses of economic agents, public consumption is adjusted in order to meet the government budget constraint. The simulation results are reported in Table 1.

Labor supply
A lower marginal tax rate in the first or second bracket boosts aggregate labor supply (in hours) because the substitution effect dominates the income effect (see the first two columns of Table 1). A lower tax rate in the first bracket raises, especially, the labor supply of partners. This is because partners tend to work in part-time jobs with relatively low annual labor incomes. Hence, their marginal labor income is typically subject to the tax rate in the first bracket. A cut in this tax rate therefore encourages partners to work longer hours, especially in view of the relatively large uncompensated wage elasticity of partners' labor supply.

Table 1 Long-run effects according to MIMIC of four types of tax reduction by 0.5% GDP, financed by a reduction in government expenditure[a]

	income tax rates		tax deduction	
	first bracket	second bracket	basic	wage
level in 1998	8.9	50.0	8600[b]	3100[b]
change	− 1.2	− 6.9	650[b]	925[b]
Prices	*percentage changes*			
Wage rate	− 0.4	− 0.3	− 0.1	− 0.5
Production price	− 0.4	− 0.4	− 0.1	− 0.6
Consumption price	− 0.3	− 0.3	− 0.1	− 0.4
Volumes				
Private consumption	1.3	1.3	0.9	1.4
Production	0.8	0.8	0.2	1.1
Employment	0.6	0.6	0.1	0.9
– unskilled	0.8	0.5	0.1	1.5
– low skilled	0.7	0.5	0.0	1.0
– high skilled	0.6	0.7	0.1	0.8
Labor supply (persons)	0.1	0.1	− 0.2	0.3
Labor supply (hours)	0.2	0.2	− 0.1	0.1
– breadwinners	0.0	0.2	0.0	0.0
– partners	0.7	0.0	− 0.4	0.8
– single persons	0.2	0.4	− 0.1	0.0
Black labor (hours)	− 0.2	− 1.1	0.3	0.0
Human capital (index)	0.1	0.1	0.0	0.1
Ratios	*absolute changes*			
Unemployment rate	− 0.3	− 0.2	− 0.1	− 0.5
– unskilled	− 0.4	− 0.3	− 0.2	− 0.8
– low skilled	− 0.3	− 0.2	− 0.2	− 0.6
– high skilled	− 0.2	− 0.2	− 0.1	− 0.5
Share of long–term unemployment	− 1.4	− 1.3	− 0.8	− 2.9
Replacement ratio	− 0.1	− 0.4	0.3	− 0.7
Average burden[c]	− 0.7	− 0.7	− 0.4	− 1.0
Marginal burden[c]	− 0.7	− 1.9	− 0.1	− 0.6
Government consumption[d]	− 0.3	− 0.3	− 0.5	− 0.2

[a] Cumulated differences between simulation and base projection
[b] In guilders
[c] Weighted average of the micro burdens of individuals
[d] Closure rule, in percentage of GDP

Breadwinners tend to earn higher labor incomes than their partners do. Indeed, the incomes of many of these workers fall into the second tax bracket. A lower tax rate in the first bracket reduces the average tax rate without affecting the marginal tax rate of those who fall into the second bracket. The inframarginal character of the tax cut in the first bracket for many breadwinners explains why such a cut barely affects aggregate labor supply of breadwinners.

In contrast to tax cuts in the first bracket, tax cuts in the second bracket are effective in stimulating the labor supply of breadwinners. Although this group features a relatively low labor-supply elasticity, the impact of tax cuts in the higher tax brackets on aggregate labor supply (in hours) is substantial because breadwinners and single persons account for a large share of aggregate labor supply.

The third column of Table 1 reveals that a higher basic tax deduction reduces aggregate labor supply. The reason is that the tax deduction reduces the average tax burden, but leaves the marginal tax burden for most workers unchanged. Hence, the substitution effect is zero, while the income effect exerts a negative impact on labor supply.

Finally, we consider a change in the special tax deduction for workers. In the current Dutch tax system, this amounts to a deduction of 12% of the gross labor income below DFL 26,000, with a maximum tax deduction of DFL 3,100. The fourth column of Table 1 shows the effects of an increase in both the percentage tax deduction and the maximum deduction. We find that the lower marginal tax rate on part-time jobs induces substitution from leisure to consumption. Accordingly, labor supply increases. However, people with full-time jobs typically deduct the maximum amount. Hence, whereas their marginal tax remains unchanged, they experience a lower average tax burden. Through the income effect, these households tend to reduce their labor supply. On balance, aggregate labor supply increases.

Black labor supply

A lower tax burden can affect the black labor market through three channels. First, lower marginal tax rates make the option of black labor supply less attractive compared to formal labor. Second, the reduction in the average tax burden stimulates private consumption, including the consumption of black labor-intensive services. Finally, the reduction in the average tax rate reduces the formal wage rate. Accordingly, firms find it more attrac-

tive to hire formal labor, rather than black labor. On balance, the table reveals that the black economy shrinks in most experiments. Only in the case of a higher basic tax deduction, the black market expands – as the second effect dominates.

Quality of labor supply
Table 1 reveals that lower marginal tax rates and a tax deduction for workers stimulate training activities. The associated rise in human capital boosts labor productivity. Hence, the expansion of production exceeds that of employment in these experiments. A higher basic tax deduction does not encourage training.

Replacement rate
A reduction in the first tax bracket is more or less neutral with respect to the replacement rate. In contrast, the unemployed benefit relatively more from a higher basic tax deduction than do the employed because the unemployed typically collect lower incomes than the employed. Hence, the replacement rate increases. A lower tax rate in the second bracket or a higher tax deduction for workers reduces the replacement rate.

Wages, employment and unemployment
The rise in aggregate labor supply in most experiments reduces wages. This effect is reinforced by the lower average tax burden and, in some cases, by a reduction in the replacement rate. In contrast, a lower marginal tax burden exerts some upward pressure on wages. On balance, the table reveals that gross wages drop in all experiments.

A reduction in wage costs boosts employment. The higher tax deduction for workers causes the biggest expansion in employment due to the substantial reduction in the replacement rate. Lower marginal tax rates are also effective ways to increase the number of jobs, in part due to the stimulating effect on the labor supply.

The effect on the unemployment rate is determined by the difference between the effect on the labor supply and employment. A lower tax rate in the first bracket proves to be somewhat more effective in fighting unemployment than a reduced rate in the second bracket This is because it combines a similar reduction in the average tax rate with a smaller reduction in the marginal tax. The tax deduction for workers is the most effective instrument to reduce the unemployment rate. In particular, the large decline in the replacement rate improves the efficiency of the matching process by raising the search intensity of the unemployed and reducing their reservation wage.

Future research
To make MIMIC more transparent for outsiders, we have developed a core model of only 19 equations to illustrate the main economic mechanisms in MIMIC (Bovenberg et al., 1998). Furthermore, we have carried out a sensitivity analysis with MIMIC for parameters that suffer from a weak empirical basis (Nieuwenhuis and Boone, 1998). Our future research agenda involves a further strengthening of the empirical base of the model. Furthermore, we will investigate whether MIMIC can explain historical developments in the Dutch economy. Another priority for future research is to better model active labor-market policies. Finally, MIMIC will be used to explore the welfare implications of tax reforms and to derive optimal tax policies.

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Notes
[1] A more detailed description of MIMIC can be found in Graafland and de Mooij (1998). A description of the matching model for long-term unemployed is given in Jongen and Graafland (1998).