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Long-term macroeconometric models
The case of Poland

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ABSTRACT

Long-term forecasts and scenario analysis should be based on macroeconometric models. The core of long-term models is extended by introducing production functions generating potential output. Their specification includes total factor productivity (TFP) being representative of technological progress. It depends on knowledge capital, i.e. human capital, domestic and foreign R&D. Several channels of transfer of foreign R&D can be distinguished.

The potential output differs from the effective output, representing final demand, underlying business cycle fluctuations. To study potential disequilibria a system of equations explaining final demand must be established. Thus the long-term macroeconometric model must be a complete model. Its use may cover long-term forecasts and scenario analysis based on model simulations.

The paper outlines the above specifications of the long-term model using as example a new model of the Polish economy. The model is medium-sized. It covers demand and supply side, including prices and financial flows. The results of multiplier analysis are shown revealing model feedbacks, including generation of business cycles. The results of its application are shown: long-term forecasts up to the year 2030 as well as scenarios of development of the Polish economy, including recession scenario.

1. Introduction

In the last decades the growth of "new" modern market economics was associated with the rapid development of knowledge capital. Its impact became the major factor of economic growth, outperforming the investment in fixed capital and labour increase. Hence, the economic community has come to a common conclusion that the contemporary economies gravitate to a structure known as a knowledge-based economy. This concept has been formulated in contrast to an industrial economy system that prevailed in the last centuries (Smith, 2002). Even though the earlier economic systems also took advantage of knowledge that determined their technological progress, at the turn of the 20th century the role of knowledge capital started to dominate in the functioning of economies as a result of automation of manufacturing processes, speedy distribution of management information (recently via the Internet), and in economic growth related to endogenisation of technological progress, mainly due to the development of the Information and Communication Technology (ICT).

There is vast literature based on new theories of endogenous growth aimed to explain – at the world-wide level – the differences in the rates of growth of particular countries and the issues in their convergence. It is based on an analysis of international cross-section samples and emphasizes the role of particular factors of growth. The explanation of total factor productivity (TFP) growth including the impact of domestic and foreign R&D expenditures and human capital was studied from many different points of view (see Welfe, 2007b, 2009c). The generation, absorption and use of the many forms of knowledge capital, were the subject of many empirical studies. Their non-technical excellent summary can be found in Helpman (2004).

The results of this research are rather exceptionally applied to investigations into economic growth of single economies, except for the US economy. The in depth studies led by Professor Jorgenson (Jorgenson et al., 2003, see also Richards, 2000) are worth mentioning. It applies also for Poland (see Welfe, 2001). This has a practical aspect, too. The authorities and the scientific community of a country need to have an instrument that will help construct scenarios of long-term economic growth for 20–30 years ahead.

All these studies were concentrated on the supply side of the economy. Of course, the knowledge of a long-term, extended production function with endogenous TFP being dependent of knowledge capital embodied it fixed capital and labour is a prerequisite of such studies. However, this instrument allows to generate potential output only. It may considerably diverge from effective output which represents realizations of final demand that underlie business cycle fluctuations. Hence, to be used in empirical analysis and simulation exercises we need to construct a complete model that contains both the

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final demand and the total supplies. That makes possible to estimate the likely disequilibria: output gap, unemployment, foreign trade deficits, etc. The model should be closed by introduction price, wage and financial flow sector.

All this justifies the need for construction of extended, long term macroeconometric models for single economies (W. Welfe, 2008a). We tried to show their suggested structure using as an example the annual long-term macroeconometric models W8D built for the Polish economy. Their characteristic is provided in the following section. Next sections of this paper contain discussions of properties of many alternative measures of major determinants of economic growth, the alternative approaches to their explanation with an attempt to show the interdependencies within the whole economic system. The role of investment in fixed capital and knowledge capital is discussed in the light of multiplier analysis. The applications in scenario analyses based on model simulations are provided at the end of the paper.

2. The macroeconometric models of a knowledge-based economy

The quantitative mechanisms that underlie the growth of a knowledge-based economy can be described empirically by means of adequately expanded macroeconometric models. Such models should draw on economic growth theory which has been enjoying its renaissance, and especially on endogenous growth theory (see Grossman and Helpman, 1991; Barro and Sala-i-Martin, 1995; Aghion and Howitt, 1999, and more recently Nahuis, 2003; Tokarski, 2001, 2007).

The long-term macroeconometric models built along these lines, extended to include processes in which knowledge capital is generated and used, seem to be the most relevant tools of long-term economic analysis. Their structure may follow the framework of the mainstream models outlined by Klein et al. (1999). See also Bodkin et al., 1991 and Whitley, 1994.

These models specify the final demand equations along the neo-Keynesian lines, but the potential output and demand for the factors of production, as well as impacts of technological progress they generate referring to the neoclassical theory of production (Solow, 1957). This approach draws on the early theories of growth developed by Harrod and Domar and on the concept of models of production possibility frontier that have recently been developed by Jorgenson (2000). The stylized empirical model of growth by W. Welfe (2005) follows a similar approach.

In Poland empirical investigations referring to the above developments build on the concept of an empirical model of economic growth developed by Welfe (2000). This concept gave rise to the construction of the long-term macroeconometric models of the Polish economy W8D (see Welfe, 2001, 2004 and recently W8D2007 in 2008a, 2009a).

The W8D models were built to encourage studies of the evolution of Polish economy towards a knowledge-based economy and elaboration of long-term scenarios reaching the years 2020–2030 (Welfe, 2009b). More specifically, the models enabled a thorough analysis of the impacts of endogenous technological progress, or rather of the changes in knowledge capital the progress induces, while allowing for relevant feedbacks.

The new, long-term model W8D 2007 is a complete structure. Its quantitative description is shown in Table 1. It is one sectoral, medium-sized model (see W. Welfe, 2008b, 2009a).

The core of its simulation version comprises several blocks of equations, traditionally following the familiar classification of economic activities. The blocks explain:

- final demand, including exports and imports;
- the supply side, including potential output, and the primary factors of production;
- impact of technological progress (TFP); and
- prices and wages and financial flows.

Table 1
Major characteristics of the model W8D-2007.

Characteristics	The number of variables/equations
Variables total	393
- Excluding dummies	258
- Exogenous (E)	157
- Excluding dummies	22
- Endogenous	235
Equations — total	235
- Stochastic (B)	111
- Identities (I)	124
Lags, leads	
- Maximal lag	8
- Maximal lead	0
-Lags total (L)	165
-Leads total (W)	0
Endogenous variables	
- Presimultaneous	24
- Jointly determined	80
- Post simulataneous	131
Feedback variables	7
Equations by blocks	
Final demand — total	64
- Domestic	34
- Foreign	19
- Macroaggregates	11
Production factors	17
Technical progress	40
Potential output	7
Average wages and incomes	12
Prices, deflators	36
Financial flows	48
- Money markets	16
- State budget;	18
- Balance of payment	14
Macrocharacteristics	11

The final demand block explains private and government consumption, investments and foreign trade. In the next blocks, the long-run potential output is generated, depending on fixed capital, labour and TFP determinants, i.e. human capital per employee and cumulative R&D expenditures, both domestic and foreign. The direct and indirect channels of the transfer of foreign knowledge capital – via imports – are distinguished. The indirect channels comprise knowledge capital embodied in imports of investment goods and/or imports of high-tech and low-tech products.

The role of investment as a factor determining an increase in potential output as well as in final demand is emphasized. It offers the possibility of studying potential disequilibria in the commodity markets in the long run.

The last blocks of the model are prices and financial flows. Prices react to disequilibria and changes in costs, while wages are formed in the course of negotiations. The financial flows are explained within particular institutional sectors.

The economic mechanisms represented in the system of models' equations can be summarized in the following manner. There are familiar feedbacks identifying relationships that occur in the production sector among: a) consumption, production and employment (the consumption multiplier), b) investment and production (the accelerator), c) production and the financial sector; the relationships are transmitted, *inter alia*, via the tax system and the budget (the fiscal multiplier), and d) prices and wages (the inflationary spiral). The relationships between the production sector and the financial sector are mainly taken account of by price and wage adjustments that in turn affect the intensity of the quantitative adjustments (such as changes in demand). Schematic relationships between particular blocks are illustrated in Fig. 1.

When the supply side is extended by introducing equations generating potential GDP, additional mechanisms can be observed in