Fiscal Policy Shocks in Dynamic General Equilibrium Models

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Abstract

The common theme of the three essays in my thesis is fiscal policy modeling. The general focus is on analysing the effects of several types of fiscal shocks in dynamic general equlibrium models, though the models presented naturally differ from each other in terms of the questions raised, the assumpions made and the modelling techniques applied. In each of the essays (all formerly published as separate articles, and now structured as sections of a lengthy thesis) I was aiming to demonstrate that, on the one hand, dynamic general equlibrium models shed new light on the classical questions of macroeconomics, and on the other hand, enrich our knowledge of the transmission mechanism through which fiscal policy affects the economy.

Contents

1   Introduction

In the *first section* I give a brief historical overview of the major theoretical developments in modern macreconomics and their consequences on fiscal policy modelling. A summary of the most important features of dynamic stochastic general equilibrium (DSGE) models is followed by highlighting the models' implications that are most fundamentally different from those of the traditional neoclassical synthesis framework. Among these, I put special emphasis on the following.

- *Dynamic models.* The classical Keynesian IS-LM tradition of macroeconomic modelling was static in the sense that, technically, it required solving a system of equations describing simultanous relations of all variables. The effects of an exogenous change in fiscal policy was then given by a comparative analysis of static equilibrium positions (comparative statics). This type of analysis could tell how the equilirium values of the so-called endogenous variables react to changes in the so-called exogenous ones.

  The explicitly dynamic framework allows for a richer set of analytical problems to be dicovered. Technically, discrete-time dynamic models require solving a system of difference equations. The result of this experiment is the complete dynamic paths of all the accomodating variables to the specified time-path of the shock variable (in our case, some kind of fiscal parameter), the structural parameters and initial conditions of the underlying economy. In most cases (and in all the models presented in the thesis) the system converges to a well-defined steady state that can be interpreted as the long-run equilibrium of the model.

  The dynamic framework allows for the analysis of a much richer set of fiscal experiments. The short-run and long-run effects of shocks (together with a properly specified transition path between the two) can be described and interpreted within the same structure. Moreover, the crucial difference between

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transitory and permanent shocks also make sense and a marked difference in dynamic models.

- *Expectations.* Moreover, the dynamic framework allows for future shocks, as well as the expected future values of the endogenous variables to have immediate effect on present behavior. In models that are consequent in their microeconomic foundations, the optimizing principle should also be applied to the forming of expectations: rational (forward-looking) expectations consistenly follow from the principle. This feature makes it even more pronounced that rational agents react to known future shocks in advance, while the consequences and the mechanism of the same shock can be dramatically different depending on whether it came as surpirse (and changed the expectations of economic agents) or was foreseen (and left the expctations unaltered).

- *Consumption smoothing.* The rational forward-looking behavior assumed in DSGE models substantially loosens the relation between current consumption and current income that was so pronounced in Keynesian macroeconomics. Maximizing over time the discounted sum of utility that is concave in consumpion, requires avoiding abrupt changes in consumption from one period to another. Consequently, the consumer uses financial assets (typically riskless bonds) to smooth consumption over time. In good times, savings (demand for bonds) increase and make up most of the extra income, while the "usual" level of consumption is maintained by borrowing (supply of bonds) in bad times.

  With perfect credit market, this smoothing motive will have the implication that consumption is the function of expected lifetime resources only, and practically independent of current income. Keynesian consumption function (as the relation between current consumption and current income) does not eventually exist any more, and, consequently, any multiplier effect is also deemed to fade away. The relation between fiscal policy shocks and output can still

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be important and is worth analysing, but the effect of fiscal policy is more indirect, more difficult and is simultanously influenced by (current and future values of) other variables as well.

While heuristically reasonable, and the pattern is clearly present in macro-economic time series, microeconomic evidence for consumption smoothing is far from what the fully rational behavior with perfect credit markets would imply. (See Attanasio [1998] for a review on consumption behavior.) This evidence has led many macroeconomists to introduce consumer heterogenity, a modelling tool that will also be resorted to in Section 3 of the thesis.

- *Ricardian equivalence.* Consumption smoothing implies that consumption of the rational utility maximizer depends only on the present value of lifetime resources, and, the present value given, is independent of the time-path of those resources. Consequenty, any rescheduling of the consumer's lifetime disposable income will keep consumption unchanged, unless it changes the present value of it. Moreover, in a model populated with fully rational, forward-looking agents, the goverment should observe its own budget constraint. The latter states that the goverment's ability to borrow is limited up to the present value of its future tax receipts. The two features together lead to the proposition of Ricardian equivalence (Barro [1974]). That is, if goverment expenditures are financed by non-distortive lump-sum taxes, the timing of taxes has no effect on private consumption as a mere rescheduling of tax liabilities (a tax-deficit swap) keeps households' lifetime disposable income unaltered.

  Even though both the highly restrictive assumptions behind and the practi-cal relevance of the proposition are debated in the theoretical and empirical literature (for a review see Barro [1989], Bernheim [1987], Seater [1993]) the proposition of Ricardian equivalence definitely had a path-breaking role in our understanding of fiscal policy. It logically pointed to the corollary that the

consequences of a goverment deficit or debt position that is considered unsustainable can be crucially different according to private sector's beliefs on the resolution of the situation, that is, whether the goverment is expected to raise taxes, resort to seigniorage revenues or cut back expenditures to overcome the difficulties, and whether the declared plans are seen as credible by the public. A declaration and introduction of a stabilization package relying on the reduction of expenditures that is considered credible by the public, can have non-Keynesian effects. That is, by reducing the future tax burden of the private sector and by mitigating uncertainties about the future conduct of fiscal policy, such a plan can, contrary to the classical Keynesian arguments, boost aggregate demand and have a positive effect on output (see Giavazzi-Pagano [1990], [1996], Perotti [1999]).

- *Supply-side effects.* The classical Keynesian argument simply assumed unexploited capacities to arrive to the proposition that supply will simply and passively accomodate to any shock in aggregate demand. Taking microeconomic foundations seriously and applying them consistently requires modelling the supply side of the economy as resulting from optimizing (profit maximizing) behavior of the production sector. Fiscal shocks can affect aggregate supply through a variety of chanels. The effects can be direct, as in the case of public investments that change the stock of productive inputs in the economy, as well as the productivity of private inputs. More generally though, fiscal steps can have an indirect impact on the economy-wide relative prices. In new Keynesian models with nominal rigidities, the change in relative prices is partly due to the fact that shocks in aggregate demand have different effects on nominal variables both in terms of the magnitude and the speed of the reaction. But the supply-side effects – as presented in the next section – play a role in fully supply-driven real business cycle models (lacking monetary models, and hence nominal variables altogether) as well. It follows that in these models fiscal

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policy shocks can only influence aggregate bahavior through modifying the supply of and demand for private productive inputs.

Clarifying the supply-side effects contributes to a better understanding of the consequences of various kinds of fiscal shocks. It draws attention to the fact that it is not only the overall level of goverment expenditures and receipts that counts, but also the specific purposes that expenditures are used for and the specific ways taxes are levied and collected from the private sector. Moreover, differences in these specificities can not only have minor quantitative consequences on the results, but can dramatically alter the sign of the effects as well (and turn an expansionary effect restrictive, or vice versa).

With the above-listed features in mind, I give a survey of the literature about modeling *fiscal policy experiments in DSGE framework*. An introduction of a generic model (originally presented by Baxter-King [1993], inspired by Aschauer [1985, 1988] and Barro [1989]) is followed by a brief overview of the most popular theoretical models from the *RBC tradition* (given by Ludvigson [1996] and Fatás-Mihov [2001]). Edelberg-Eichenbaum-Fischer [1999] and Burnside-Eichenbaum-Fischer [2003] introduce real rigidities (capital adjustment costs and habit formation) to otherwise standard real business cycle models to improve on the empirical fitting of these models. Karalajcin [1999], Daban-Herczovitz [1998] and Ramey-Shapiro [1997] extend the framework to incorporate an open economy, while Rotemberg-Woodford [1993] introduce a monopolistically competitive product market to the standard neoclassical setup.

The effects of public investment were first analysed by Aschauer [1989], and gained widespread interest later in the various models of *endogenous growth theory*, inspired mostly by Barro [1990] and Barro–Sala-i-Martin [1992, 1999].

As for the *new Keyesian tradition*, a generic model with nominal rigidities is given by Gali [2005] and Gali–Lopez-Salido–Valles [2007]. The classical open-economy extension is the famous redux model by Obsfeld-Rogoff [1995] who present a two-

country model with implications on the international repercussions of fiscal shocks. Bilbiie-Straub [2004] and Ganelli [2005] follow the new Keynesian tradition by assuming price and wage rigidities, but constraint their analysis to the small-country setup.

In the *empirical literature*, rigorous studies applying vector autoregressive methods aim at identifying the usual reactions of the aggregate variables to the exogenous shocks in fiscal policy (see for example Blanchard-Perrotti [2002], Fatas-Mihov [2001], Christiano-Eichenbaum [1992], Edelberg-Eichenbaum-Rebelo [1999], Burnside-Eichenbaum-Rebelo [2003], Ramey-Shapiro [1997], Gali-Lopez-Salido-Valles [2007], Ravn–Schmitt-Grohe-Uribe [2007], Monacelli-Perotti [2006] and Beetsma et al. [2006]).

The most widely documented empirical features, the so-called *stylised facts* include the persistent increase in output and private consumption following a fiscal expansion. (Though it is worth noting that the way of identifying the exogenous shocks proved to be important in the empirical results. See Ramey-Shapiro [1997] for an overview.) Employment and real wages are higher, and so is the real interest rate. As for the open-economy indicators, even though the quantitative differences are important, the literature is surprisingly unanimous in finding the real exchange rate appreciating and the current account "worsenig" (external deficit growing) in face of an increase in fiscal spending. The reaction of private investments can be very different according to the composition of the public spending, while over the long run, output growth is negatively correlated with measures of the budget deficit.

2 On the mechanisms of fiscal policy shocks: Frictionless models – supply-side effects

In *section 2* of the dissertation, potential supply side effects of a fiscal expansion are examined. In order to concentrate on real adjustments I assume away any kind of difficulties stemming from nominal adjustment problems (effectively I ignore the existence of the monetary sector whatsoever). The language of macroeconomics calls these models supply oriented, or supply driven. I use this approach to analyze reactions to different kind of fiscal shocks. My models can illustrate how fiscal policy actions - through the mediation of income and substitution effects they generate - force rational decision makers to adjust their behavior. This adjustment shows up in movements of aggregate macroeconomic variables. The significant result of these frictionless real models is that adjustment of macroeconomic variables to fiscal shocks is very similar both qualitatively, and – depending on the sensitivity of the reactions of economic actors – even quantitatively to conclusions we derive from simple demand-oriented Keynesian models.

In *Keynesian models* (Keynes [1936], Hicks [1937]) the indicator of aggregate economic performance, the national output moves strongly together with the level changes in government expenditures. Our models prove that this strong statistical co-movement between these variables (also refered to as the high procyclicality of goverment spending) can be reproduced by supply-side mechanisms alone. The significance of this conclusion is particularly underlined by the fact that IS-LM type Keynesian models derive their long-lasting popularity in economic policy discussions and – in their contemporary New-Keynesian variations – academic debates from their excellent fit to the empirical data and stilized facts. They can still serve as a general framework for interpreting fiscal policy because they seem to be the best fit to the economic data. If, however, supply-driven real models can reproduce the same type of movement in the macroeconomic variables, than one does not have to stick to

demand-oriented moldels.

Following the chronological order of the history of economic thought first I discuss the main features of the *Solow growth model* (Solow [1956]). Although in its basic variant the Solow growth model does not include government expenditures, it can be added to it without any difficulty. The main thrust of this model is the analysis of the process of capital accumulation. From this point of view, what really counts is the allocation of output between consumption and saving/investment. The question that who, which economic actor is doing the investing, is immaterial.

Productive capacity is fully utilized in the Solow model ("we are in the long run"). Therefore, if one adds an additional spending item (government spending) to the existing consumption and private investment, this can increase only at the expense of the other spending categories. Government spending can either be in the nature of consumption or investment. However, if the model's sole "behavioral" parameter, the aggregate ("national") saving rate, is exogenous (as it is always assumed given in the Solow model), then saving and accumulation conducted by the government sector would increase the share of investment in total output. Therefore, government investment has to crowd out private investment, otherwise the saving rate would change. On the other hand, if government spending is in the nature of consumption, then it must crowd out private consumption, as output is given (determined by the supply side). The level of output is not influenced by government spending neither in the steady state, nor in the transition period while the economy approaches the steady state.

The next step is to introduce the *Ramsey-type model of dynamic optimization* (Ramsey [1928], Caas [1965], Koopmans [1965] for a modern textbook exposition, see Romer [1996]). The novelty of the Ramsey model is that the main "driving force" of the dynamic process of producing output along the time path, the consumption/saving decision is modeled in it as an explicit decision making process, it is the result of an optimal decision. Therefore this model would give an opportunity

to analyse supply side effects, however, the only consequence of a fiscal expansion in this model is a negative income (wealth) effect on the consumer. In order to increase its spending, the government has to raise taxes. The consumer, who optimizes along her life-path, anticipates the decrease in her expected life time disposable income due to the increase in the tax level and reacts to it. In case of a *permanent* increase in the tax level, the well-informed consumer knows that she is unable to improve on her position (lifetime utility) through reallocating her consumption across different time periods. The optimal reaction to a permanent tax increase therefore is that she immediately reduces her consumption level in every period exactly by the amount of the additional levy collected from her. The level of national (private plus government) saving would not change. The fiscal policy action does not have any effect on output.

In case of a *temporary* fiscal policy move, the consumer tries to smooth out her consumption across periods. The decline in her consumption will be smaller than the increase in government expenditures (and taxes). Therefore national saving temporarily decreases and so does capital stock, as well as production . There is a cycle generated by fiscal policy in the macroeconomic variables, however both consumption and output decline before they returns to their original levels. This shape of adjustment path, however contradicts stylized facts derived from empirical observations.

If we introduce elastic labor supply into the model that performs optimization over infinite time horizon, we get to the *Real Business Cycle (RBC) model* (Kydland-Prescott [1982], for a suvey on RBC models, see King-Rebelo [2000]). In this framework the optimizing consumer is made to change her labor supply as a result of an increase in government expenditure. First, fiscal expansion (that is, an increase in taxes from the point of view of the consumer) takes resources away from the consumer, she experiences a decline in her lifetime disposable income. Due to this decline in her wealth, she reduces her demand for consumption goods, as well as

for leisure (since under the canonical specification of her utility function, both of those useful things are normal goods). Decline in her demand for leisure means an increase in labor supply. Therefore, the *income effect* of the decrease in her net lifetime income in itself results in an increasing labor supply. Moreover, as the tax levy takes only consumption goods away from the consumer, she experiences not only a simple decline in her lifetime resources, but that part of her wealth that exists in the form of consumption goods becomes relatively scarce while the one in the form of leisure becomes relatively abundant. The decline in her endowment is therefore asymmetric, the consumer launches intertemporal substitution favoring consumption at the expense of leisure, the *intratemporal substitution effect* strengthens the income effect discussed before. Moreover, if the fiscal expansion is temporary, then it causes a temporary increase in the real interest rate constituting a third channel which goes through *intertemporal substitution* and also adds to the factors increasing labor supply. The increase in the labor supply results in an increase in output. Therefore, the behavior of output depends on how elastic labor supply is, in case of a large enough elasticity, the RBC model can also reproduce the positive relationship between fiscal expansion and the increase of the output level.

3 Redistributive fiscal expansion in a small open economy

Effects of fiscal policy are discussed in a *two-sector small open economy model* in the third section of the dissertation. Fiscal policy here is a redistribution of resources between two actors. A fiscal policy action is considered to be expansive if it increases the level of redistribution. With plausible assumptions made on the consumption structures of both the beneficiaries and the "losers" of this reallocation, the results of my model show that an RBC-type model of a two-sector small open economy (similar to and inspired by the textbook exposition in Obstfeld-Rogoff [1996]) can reproduce a number of adjustment features summarised in the stylized facts of empirical observations discussed in the literature at length. For example, as also cited above, the effect fiscal expansion exerts on enhancing output, it increases consumption and the real wage, while the real exchange rate appreciates and we experience a "worsening" in the international balance of payments (increase in foreign debt). The empirical literature is especially rich in analysing the so-called twin-deficit hypothesis, that is the tendency of the external balance to worsen in face of a positiv shock in public spending. (See Normandin [1999], Khalid–Guan [1999], Kaufmann–Scharler–Winckler [2002], Kormendi–Protopapadakis [2004]). A model like the one presented here can give fruitful insights even into the macroeconomic developments experienced in Hungary around 2002 when the government launched a largescale increase in transfer payments, the programme called "change in the welfare system".

The model has two types of consumers. This feature follows the mainstream of contemporary models that admit the fact that aggregate consumption behavior cannot be properly described solely by the representative consumer optimizing over an infinite horizon (see Campbell-Mankiw [1989], Mankiw [2000], Gali [2005]). Models introducing *heterogenous groups of consumers* seem to be more applicable

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to describe household sector's reactions to fiscal policy shocks. Therefore, in my model I introduce a regular, Ricardian consumer from whom the fiscal policy action allocates income away, but we also have a "shortsighted" (or non-Ricardian) consumer, the beneficiary of income redistribution, who consumes whatever amount of income the government allocates to her at once. This latter actor also differs from the type of consumer we regularly deal with in RBC models that she does not participate in the labor market, does not supply, or inelastically supplies labor (in fixed amount). Moreover, her consumption consists exclusively of nontradable goods (say, services), the ones that are not exported or imported. The only function the government performs in this model is that it reallocates income between these two groups of consumers. That is, the government taxes income away from Ricardian consumers, reallocates those incomes to non-Ricardian consumers and the latter spend the whole sum on purchasing nontradables (services).

Apart from consumer heterogenity, there are two types of real frictions in the model. First, new stocks of capital are costly to install, in the spirit of Tobin's q model (see the textbook exposition in Romer [1996]). *Capital adjustment costs* slow down the economy's adjustment to shocks, and as such play an important role in delivering current account persistence (that would simply be absent from frictionless real models of a small economy). Second, the country faces an upward-sloping supply of foreign bonds, thus it has to pay interest rate premium if the economy's net external debt increases. The *interest rate premium* function applied in the model is a slight modification of the one proposed by Schmitt-Grohe–Uribe [2002].

If in this framework the *government temporarily raises the rate of income redistribution*, then non-Ricardian consumers (by assumption) raise their consumption of nontradable goods by the amount they receive from the government. Due to the decline in their lifetime incomes they experience, Ricardian consumers cut back their consumption out of both tradable and nontradable goods. However, as Ri-

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cardian consumers smooth their consumption over time, *total consumption increase* altogether. Therefore, this demand-side shock increases the output in the nontradable (service) sector. The structure of total consumption also changes, the share of nontradables in demand increases. Nontradables become relatively scarce, their relative price increases. This relative price is by definition the internal *real exchange rate* which *appreciates.*

Moreover, following the logic of the RBC framework, Ricardian households *increase* their *labor supply.* Employment changes, however, will be different in the two sectors. As the relative price of the nontradable good increases, the marginal productivity of labor in the service sector increases. Labor will move from the tradable into the nontradable sector. Reallocation of labor favoring the service sector will last up until real wages in the two sectors become equal again. Additional labor employed in the nontradable sector makes capital relatively scarce in that sector. Accumulation (reallocation) of capital is required for optimal adjustment. From the point of view of capital adjustment, the tradable sector moves to the opposite direction. Capital is depleted, just like labor, capital also moves to the nontradable sector. Without adjustment costs these movements of capital would set capital and labor ratio to the level of steady state equilibrium immediately. The existence of adjustment costs makes this adjustment much longer in time. Immediate adjustment in labor and postponed movement of capital together make the labor input in the whole economy relatively scarce, therefore *real wages increase.* Output in each sector will be determined by the movement of resources respectively. It decreases in the tradable and increases in the nontradable sector. *GDP,* the sum of the output produced by the two sectors measured in the common numeraire, *will also increase.*

External balance is determined by the state of the market for tradable goods (current output in the nontradable sector is always matched by demand for that good.). Due to labor moving away from the tradable sector, output decreases in that sector. On the demand side, consumption demand raised by the Ricardian consumers

decreases due to the decline in their lifetime income, although, provided the shock is temporary, this decline is dampened due to consumption smoothing. Investment increases due mainly to the capital accumulation experienced in the nontradable sector. Level of net foreign assets decreases altogether (or alternatively, *foreign debt increases*). Net exports, however will show a surplus along the adjustment period in order to counterbalance the initial "twin deficit".

We emphasize two pieces of theoretical results in this part. First, we can show that model results match stylized facts of empirical evidence. Monetary sector of the economy was not needed to mimic empirical data. What this means is that expected results can be derived from a solely real model, which is much simpler than the standard New-Keynesian framework with nominal (price and wage) rigidities. Moreover, if the same adjustment is derived from a model lacking monetary sector whatsoever, it can shed new light on the current economic policy debate on the role of Central Bank and monetary policy in determining real exchange rate. Restrictive monetary policy conducted by the Hungarian Central Bank is often cited as the main reason for real appreciation of the national currency. If, however, real appreciation can be reproduced as a result of fiscal stimulus alone, in a model not even having a monetary sector, then the role of the Central Bank may not be that important in this process after all.

4 Goverment investment in a small open economy

In this section, effects of government investments in a small open economy environment are analysed. Apart from enhancing the country's output directly, government spending on capital – modeled here as development of public infrastructure – would create positive external ecomony in the production process of the private sector. Short and long run effects of ambitious goverment development programmes depending on the source of financing (transfers from abroad as well as the availability of loans), are addressed. The empirical relevance of the quantitative conclusions to be derived from the present stilized form of the model is admittedly limited. However, the qualitative conclusions driven from it can shed new light on some issues and contribute to the contemporary debate on the expected effects of government investments and EU transfers on macroeconomic development.

General *equilibrium modelling of government investments* started with Ashauer's [1987], [1989a] papers in the end of the 1980's. Government investment in these articles is modeled as purchases of public goods that – unlike government consumption – are useful not just by themselves, but they create positive external effects by improving production opportunities opened to the private sector. Spending on public infrastructure by the government therefores enhance production, via influencing the supply side. Formally: public capital is entered the production funcion of the private producer sector as a supplementary productive resource. This way infrastrucure investments would directly increase production for any level of private capital and employment. Moreover, with usual and not too restrictive assumptions made on the production function, higher level of public infrastrucuture rises the productivity of the private capital (and perhaps the one of labor), therefore it results in investment (employment) boom as well.

The way government investment into infrastructure influences accumulation of private capital and economic growth is regularly modelled in the framework of the *endogenous growth* models. A rich discussion of the basic structures is given for

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example in the works of Barro [1990] and Barro–Sala-i-Martin [1992], [1999]. In the Hungarian literature we know of, Valentinyi [2000], [2002] used similar model specifications while analyzing the impact of fiscal policy (spending and tax structure) on the convergence process in the medium and long run.

From the theoretical point of view this section draws upon this framework. Questions and certain model solutions, however, are somewhat different from the standard issues raised by the growth theory. Rather than looking for the sources of long run economic growth, it aims to describe the path of macroeconomic adjustment to development programs. Determinants of the long run economic performance are treated as given, and as such, are simplified out of the model.

Chatterjee-Turnovsky [2004], [2005] find it warranted to assume, that the efficiency of government invesment depends on the (intratemporal) elasticity of substitution of inputs included into the production function, as the degree of this substitution would influence the time path of private capital adjustment to projects of infrastructure development. This elasticity of substitution can be a matter of empirical investigation. The reason for using a general constant elasticity of substitution (CES) type production function was just that it – unlike the rigid, unitary elastic Cobb-Douglas production funtion – offers more opportunity to describe the consequences of alternative degrees of substitution among inputs.

Empirical tests and discussions of the problem also gained momentum from Ashauer's [1989a], [1989b], [1989c] series of articles. He also tested a macroeconomic production function augmented by public infrastructure on US time series data between 1949-1985 (Ashauer [1989a]). He concluded that the US economic performance depended decisively on public infrastructure and that the productivity slowdown that started in the 1970's can largely be attributed to the downfall of public investments. Munnel's [1990] results support the hypothesis that public investments have significant effect on productivity and that they also crowd in private investments.

Calculations conducted by Ashauer and Munnel attracted special attention and also started a political campaign. (The "Reconstruction of America" plan that aimed at revitalizing public investments was an important part of President Clinton's election campaign in 1992.) The academic community was much less impressed and attacked several points of the Ashauer-Munnel results because they looked "too good". According to Gramlich [1994], it is suspicious that if we use the kind of macroeconoic parameters found in Ashauer's studies, we would end up with urealisticly high rates of returns (around a 100 percent a year) on infrastructural investments. At these rates of returns taxpayers would noisily demand much higher levels of public investments. As they do not do that, this revealed preference is a clear sign that the estimates are overly optimistic.

Testing Granger causality between the level of public capital and productivity, Tatom [1993] found a reverse relationship. While neither the level of public capital, nor government investment Granger-caused increases in productivity, changes in total factor productivity Granger-caused changes in the level and rates of investment into public capital.

International cross section estimates give a somevhat clearer picture, government investments in most of these tests show significantly positive impact. Easterly-Rebelo [1993] finds a positive effect of public investments in traffic and communication on long run economic growth. The same kind of positive impact is shown by Sanchez-Robles [1998] in a regression using the length of the railways and roads, the electric power supply and the number of telephone lines as independent variables, while Easterly [2001] used the number of phone lines per capita to produce the same result. Romp-de Haan [2005] provide an extensive survey of the recent literature, and conclude that the international evidence supports the positive role of public infrastrcture in enhancing output, though the results fall short of the overly optimistic Ashauer-Munnel results.

In Hungary there has been a long tradition of research to describe and docu-

ment the state of affairs in public infrstructure using extensive sets of quantitative and qualitative indicators and international comparisons (see for example Ehrlich (ed.) [2003]). These works, however, never relied on formal theoretical macroeconomic models. Efficiency of government investments is of great interest, however, empirical studies relying on theoretical models are scarce. Even those avaliable restict themselves on the corporate and regional level of the problem, studies dealing with the macroeconomic consequences are practically non-existent. Békés-Muraközy [2005] tests firm level production function on a sample of panel data from 1992-2001. According to their results, government investments have positive influence on the productivity of firms in the sample. They found similar positive impact exerted by density of the main road system around the area the firms were located. Németh [2005] analyses the impact of highway building projects.

In our model the representative household and firm follow their objectives taken the goverment's decisions on the stock of public capital as given. The private sector's supply and demand decisions derived from the optimization problem, together with the market equiibrium conditions determine the path of the endogenous variables in the model. The shock is the same in all scenarios: a largescale, unexpected and permanent increase in the stock of public infrastructure. The development of public capital is by assumption prolonged and its time path is exogenously given. The scenarios analysed in the model differ in terms of the financing of a given infrastructure development project. In the first scenario, the costs are financed from internal sources (that is, taxes from the private sector), while in the second scenario, they are partly covered by foreign transfers. We conduct sensitivity analysis on how institutional characteristics of the economy (the degree of its openness to international capital markets), as well as on the "deep" parameters reflecting consumers' preferences (the degree of intertemporal substitution) and production possibilities (the degree of substitution between productive factors) influence the economy's adjustment to ambitious government plans under different financing schemes.

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Long run qualitative *conclusions* derived from the model are the same at any plausible values of the parameters chosen. In the long run the higher stock of public capital directly increases long run level of output and it also results in a higher equilibrium level of private capital stock as well. This naturally leads to higher level of steady state income (thus consumption and welfare also increase), while the higher level of depreciation of capital also raises the maintenance costs. Due to the general assumptions made in the model the type of fiscal shock introduced will not change any of the "big ratios" (capital to labor, capital to output etc.) of this economy. What the government infrastructure investment influences, is the scale of the economy only, but its internal structure is unchanged whatsoever.

As far as the *short run consequences* are concerned, productive government investment will result in an immediate upswing in consumption. Reason for this adjustment is straightforward. Forward-looking households foresee the increase in their lifetime incomes and react to this right away. In order to finance additional expenditures of new government investment projects, the government has to increase taxes as well. Although the short run increase in the tax burden levied on the households diminishes their short run net incomes. However, households know that their incomes will increase in the future, and they raise their consumption accordingly. This upward jump in the aggregate spending will certainly cause a deterioriation in the current account of the balance of payments in the short run. The worsening in the net foreign asset position will increase the rate of interest as foreign creditors charge higher risk premium. Up until the economy reaches the new equilibrium position, the government budget has to show a deficit.

In case the economy receives costless resources from abroad (these are the *foreign transfer* payments whose consequences our model is to illustrate), this relaxes the economy's resource constraint somewhat. Pressure on the balance of payment position, on the government budget position and on the rate of interest is going to be smaller. As far as the qualitative features of the model economy adjusting to a

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fiscal shock are concerned, however, they are pretty much the same, regardless of the existence of a free transfer. This is a significant result. It means that financing government capital development projects out of free foreign transfers woud make a significant difference from the point of view of how it influences welfare (consumption), however, from the point of view of the way the economy converges towards more developed economies, it does help much. What really counts in connection with the role government investment can play in enhancing development, is the openness of the economy, the ease it can access and draw upon international credit markets. If the country can access outside resource (credit-) markets, then private investments do not have to be cut back in case of an increase in both government spending and private consumption, therefore the process of convergence can be faster.

As for the sensitivity analysis of the "deep" parameters, the smaller the *elasticity of substitution* is between the productive resources, the faster the adjustment process is going to be. Our model reproduces the result generally accepted by the literature on foreign economic aid, that is, elasticity of substitution between productive resources is a particularly important factor determining the process of convergence. *Elasticity of intertemporal substitution* in consumption is also a significant factor in this respect. Stronger propensity to smooh consumption over time makes adjustment process slower, and the rate of interest is going to be higher due to the higher reliance on foreign resources driven into the economy.

The most important *conclusion* of this model is that from the point of dynamic economic growth it is easy access to international credit markets that counts and much less the free resources one can receive in the form of transfers. This conclusion draws a different, maybe more skeptical but definitely less naive picture on why one wants to join the European Union. On the other hand, as "deep" parameters describing preferences and technology of the model economy seemingly play in a role in determining the speed of convergence, it would be useful to know more about them.

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