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# OPTIMAL POLICY UNDER RESTRICTED GOVERNMENT SPENDING

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# Optimal Policy under Restricted Government Spending

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**Abstract**

Welfare ranking of policy instruments is addressed in a two-sector Ramsey model with monopoly pricing in one sector as the only distortion. When government spending is restricted, i.e. when a government is unable or unwilling to finance the required costs for implementing the optimum policy, subsidies that directly affect investment incentives may generate higher welfare effects than the direct instrument, which is a production subsidy. The driving mechanism is that an investment subsidy may be more cost effective than the direct instrument; and that the relative welfare gain from cost effectiveness can exceed the welfare loss from introducing new distortions. Moreover, it is found that the investment subsidy is gradually phased out of the welfare maximizing policy, which may be a policy combining the two subsidies, when the level of government spending is increased.

*Keywords*: welfare ranking, indirect and direct policy instruments, restricted government spending
*JEL*: E61, O21, O41

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# 1 Introduction

This paper studies the choice of policy instruments under restricted government spending, which arises when a government is unable or unwilling to use the level of spending required to implement the optimum policy. This implies that the government has to choose between alternative instruments using a predetermined and constant level of financial resources for correcting imperfections. In particular, the welfare ranking of alternative subsidies that all burden the government budget is studied. The main finding is that direct policy instruments may not generate the largest welfare effect. Instead, indirect instruments targeted on investment incentives may have more significant welfare effects. The explanation is that such instruments may be relatively cost effective. Even though new distortions are introduced, the negative welfare effect from these may be surpassed by positive welfare effects from cost effectiveness by such a magnitude that the net-welfare effect exceeds that of the direct instrument.

The standard principle for economic policy developed by Bhagwati and Ramaswami (1963) and Bhagwati (1971) suggests that instruments targeted directly on a distortion should be applied when government spending is unrestricted, because policy responses that correct distortions indirectly introduce new distortions. The policy that eliminates the distortion completely is the optimum policy and this policy will raise national welfare to the greatest extent possible. This paper suggests that direct instruments should not necessary be applied under restricted government spending since they may not lead to the largest welfare effect.[1]

The common framework applied in the literature on distortions and welfare is within the group of static, small open economy models. Consequently, indirect instruments in the form of tariffs, export subsidies, quotas etc. are introduced when the static model for the closed economy is extended to the open economy framework. In this paper, the static model for the closed economy is extended in a different dimension by using a dynamic model with physical capital accumulation. The distortion under investigation is still

[1] The standard principle is a well-established result in economics and is taught in many undergraduate as well as graduate courses. This is illustrated clearly by one of the most influential textbook of International Economics by Krugman and Obstfeld (2002, p.227-228): "It is always preferable to deal with a market failure as directly as possible, because indirect policy responses lead to unintended distortions of incentives elsewhere in the economy". Another formulation of the principle by Krugman (1996), is "the appropriate policy is always a surgical strike on the source of the distortion."

static, implying that another group of indirect instruments is introduced. These are instruments affecting investment incentives, which can be used to reduce the effects of the distortion indirectly.

The focal point of the paper is economic policy under restricted government spending. Consequently, mechanisms causing restricted government spending are not modeled formally and are not expected to change the main result if included. However, one can think of a number causing mechanisms. Restricted government spending may be a consequence of marginal costs of public funds above one, which may be due to distortional income taxes or distributional considerations, see for example Neary (1994). Alternatively, the government may not want to tax voters too heavily because they punish public expenditure, see for example Peltzman (1992). Finally, the economy may be a developing country that has only restricted access to financial resources including development aid, see for example Burnside and Dollar (2000) that report average levels of development aid as a percent of GDP equal to 2.1 in a group of low-income countries.

The analysis is related to the literature on marginal cost of public funds, where alternative taxes for financing the same amount of government spending are compared under the differential analysis, see for example Ballard (1990) and Håkonsen (1998). This type of analysis investigates the efficiency effects of financing public expenditures, while the effects of government spending are of no concern. In this paper, the efficiency effects of government spending is investigated, while the effects of public finance are of no concern.

The applied model is a simple two-sector Ramsey model of a closed economy with a representative household that supply labor services inelastically. Intermediate goods produced in a separate sector are employed as input in a final goods sector. The market form is monopoly in the intermediate sector, whereas perfect competition prevails in the final goods sector. Hence, the only distortion is monopoly pricing. This distortion implies that intermediate demand is below the social optimum. An indirect consequence of low demand is that the incentive to invest in physical capital is below the social optimum. This is an important relationship since monopoly pricing, which directly generates static inefficiency in the sector, indirectly affects the incentive to invest and thereby generates dynamic inefficiency.

To investigate whether investment subsidies can generate higher welfare gains than the direct instrument under restricted government spending, the welfare ranking of production and investment subsidies is studied for given levels of government spending. A production subsidy is a direct policy instrument to correct for monopoly pricing. This subsidy affects the static distortion directly and has an indirect impact on the incentive to invest. Thereby, a larger share of primary production factors are allocated to the intermediate sector and moreover the stock of physical capital increases. Using this instrument the government can correct completely for the monopoly distortion and make firms price according to marginal costs, provided that the optimum policy is implemented.

As a consequence of the dynamic nature of the model, a subsidy to investments in physical capital is also a relevant policy instrument. This subsidy, however, is an indirect instrument that distort the market for capital. Hence, the government introduces a new distortion in another market as a side effect when attempting to remedy the distorting effect from the original imperfection. The investment subsidy has opposite effects on welfare. On the one hand, the government distorts the market for physical capital by increasing the incentive to invest; on the other hand, this indirectly increases intermediate production. The subsidy reduces user costs relative to wages, implying that the capital labor ratios increase in both sectors. Therefore, this instrument leads to a higher capital stock but does not correct for the inefficient allocation of primary production factors across sectors.

In the remainder of the paper, the formal analysis is presented. Section 2 presents the model. Section 3 presents the main result that the investment subsidy may generate larger welfare effects than the production subsidy. Section 4 discusses the results and concludes.

# 2 The Model

## 2.1 Final Goods

Final goods are produced according to the constant returns to scale production function:

$$Y = AX^{\alpha} K_Y^{\beta} L_Y^{1-\alpha-\beta} \ , \ \ 0 < \alpha, \beta, \alpha + \beta < 1. \tag{1}$$

$Y$ is the quantity of final goods, $X$ is input of intermediate goods, $L_Y$ is labor input, and $K_Y$ is the input of physical capital.

Given the assumptions of perfect competition and profit-maximizing firms, the demand for intermediate goods, capital and labor equal:

$$X = (A\alpha/p_X)^{1/(1-\alpha)} K_Y^{\beta/(1-\alpha)} L_Y^{(1-\alpha-\beta)/(1-\alpha)} \quad (2)$$

$$K_Y = (A\beta/r_K)^{1/(1-\beta)} X^{\alpha/(1-\beta)} L_Y^{(1-\alpha-\beta)/(1-\beta)} \quad (3)$$

$$L_Y = (A(1-\alpha-\beta)/w)^{1/(\alpha+\beta)} X^{\alpha/(\alpha+\beta)} K_Y^{\beta/(\alpha+\beta)}, \quad (4)$$

where $p_X$ is the price of intermediate goods, $w$ is the wage rate, and $r_K$ is user costs of capital. $r_K = r + \delta$, where $r$ is the rate of return to capital and $\delta$ is the depreciation rate of capital. The price of final goods is used as numeraire, i.e. $p_Y = 1$.

## 2.2 Intermediate Goods

Intermediate goods are produced using the production technology represented by

$$X = GK_X^{\xi} L_X^{1-\xi}, \quad (5)$$

where $K_X$ and $L_X$ are inputs of physical capital and labor. There is market power in the sector and intermediate goods are supplied by a monopolist.

The producer of intermediate goods minimizes costs implying that the cost function equals $ucX$ with unit costs $uc = r_K^{\xi} w^{1-\xi}$ assuming $G = \xi^{-\xi}(1-\xi)^{-(1-\xi)}$. The demand for capital and labor, respectively, equal

$$K_X = \frac{\xi ucX}{r_K} = \xi \left(\frac{w}{r_K}\right)^{1-\xi} X \quad (6)$$

$$L_X = \frac{(1-\xi) ucX}{w} = (1-\xi)\left(\frac{r_K}{w}\right)^{\xi} X \quad (7)$$

The monopolist maximizes profits

$$\pi_X = (p_X - uc) X, \quad (8)$$

subject to the demand function (2). The price of intermediate goods is accordingly determined by $p_X = uc/\alpha$, which implies the market clearing quantity for intermediate goods

$$X = A\alpha^{2/(1-\alpha)} uc^{-1/(1-\alpha)} K_Y^{\beta/(1-\alpha)} L_Y^{(1-\alpha-\beta)/(1-\alpha)}.$$

The consequence of the only distortion is that the price of intermediate goods is determined as a constant mark-up over user costs. In the social optimum the intermediate price equals marginal costs.

## 2.3 Household Sector

The household sector is characterized by a representative household with an infinite time horizon. Intertemporal preferences are described by the isoelastic utility integral:

$$U = \int_0^\infty e^{-\rho t} \frac{C^{1-\theta} - 1}{1-\theta} dt. \tag{9}$$

where $\rho > 0$ is the rate of time preference, $\theta > 0$ is the inverse intertemporal elasticity of substitution, and $C$ is consumption of final goods. Utility is maximized subject to the dynamic budget constraint:

$$\dot{F} = wL + rF - C, \tag{10}$$

where $F$ is aggregate financial capital. The usual No Ponzi Game condition applies, i.e. private debt cannot increase asymptotically faster than the rate of return.

The growth rate of consumption is derived from the first-order conditions with respect to consumption, $C$, and financial assets, $F$, and equals

$$g_C = (r - \rho)/\theta \tag{11}$$

where $g_C$ indicates the growth rate of $C$.

## 2.4 Market Clearing

The equilibrium condition for the intermediate goods market is already imposed. Moreover, the labor market and the physical capital market have to clear. The solution for the production side of the economy is presented in Appendix $A$. The market clearing condition for the final goods market is derived to

$$\dot{K} = \alpha^{2\alpha} K'^{\varepsilon} L'^{1-\varepsilon} - C - \delta K \tag{12}$$

where $K'$, $L'$ and $\varepsilon$ that equal

$$\begin{aligned} K' &= K/\left(\beta + \alpha^2 \xi\right) \\ L' &= L/\left((1-\alpha-\beta) + \alpha^2 (1-\xi)\right) \\ \varepsilon &= \alpha\xi + \beta \end{aligned}$$

are used to compress the notation. See Appendix $B$ for the derivation of (12). Finally, the market for shares in the intermediate firm clears according to Walras' Law.

## 2.5 Policy Instruments and Government Spending

Monopoly power generates a distortion in pricing of intermediate goods, which calls for welfare improving policy interventions. The impact on the economy of the distortion can be seen by comparing the shares of primary production factors employed in the two sectors and the steady state capital stocks of the marked economy and the command optimum, see Appendix $D$. Variables are denoted by superscript $M$ in the marked economy and $C$ in the command optimum. It is found that $K_Y^M/K_X^M > K_Y^C/K_X^C$ and $L_Y^M/L_X^M > L_Y^C/L_X^C$, implying that the shares of capital and labor allocated to the final goods sector are too high in the market solution compared to those of the command optimum. As a consequence, the production of intermediate goods in the market equilibrium is too low. This follows directly from monopoly pricing: The monopoly distortion moves the economy away from the optimal outcome of marginal cost pricing. Since the price is determined as a constant mark-up over marginal costs, demand is below the social optimum, which reduces the demand for production factors in the sector. Moreover, as an indirect effect of monopoly pricing it can be shown that the steady state capital stock in the market solution is lower than in social optimum, i.e. $K^{M^*} < K^{C^*}$.

In the following, I compare welfare effects of alternative policy instruments. Especially, I focus on the case of restricted government spending. Hence, for some reason the government is unable or unwilling to finance the policies above a certain exogenously given level. Two policy instruments are investigated: (1) a subsidy to intermediate production (the direct instrument)[2] and (2) a subsidy to investment in physical capital that as an additional effect to increasing intermediate production distorts the market for physical capital (an indirect instrument). In the following, the two subsidies are referred to as the production subsidy and the investment subsidy, respectively.

The production subsidy covers a share of production costs. For a given

[2] The direct instrument can either be a subsidy to intermediate purchase or a subsidy to intermediate production. The subsidy to intermediate purchase reduces the price of intermediate goods by covering a share of purchasing costs, whereas the subsidy to intermediate production covers a share of production costs. In the following, I do not analyze the subsidy to intermediate purchase because it is less cost effective to implement than the production subsidy and leads to identical effects on the economy. Hence, the welfare consequences of the subsidy to intermediate purchase is always below those of the subsidy to intermediate production for a given level of government spending.

subsidy level, the direct instrument lead to an intermediate price of:

$$\bar{p} = (1 - S_X)\, uc/\alpha \tag{13}$$

where $S_X$ denotes the subsidy level. The direct effect of this instrument is an increase in the demand for intermediate goods, which is a direct static effect. Moreover, the larger demand for intermediate goods increases the demand for physical capital and thereby the incentive to invest. This implies that the direct instrument also generates an indirect dynamic effect.

The optimum policy is a subsidy level of the direct instrument equal to $S_X = (1 - \alpha)$. For this level, the distortion from monopoly pricing is fully eliminated and the purchasing price for intermediates equals the marginal costs of production. Consequently, the allocation of primary production factors between sectors resamples those of the command optimum and the steady state capital stock increases to the optimal level. The government is thus able to simulate the economic outcome a social planner who maximizes the utility of his representative household would choose.

The investment subsidy covers a cost share, $S_K$, of investment in physical capital and reduces the price of investment from 1 to $(1 - S_K)$. As a consequence, the user cost of physical capital changes to the standard expression as developed by Jorgenson (1963):

$$r_K = (1 - S_K)\,(r + \delta) - (1 - \dot{S}_K)$$

which affects unit costs of production. This subsidy is targeted on the incentive to invest in physical capital and therefore leads to a direct dynamic effect. When the subsidy is implemented, the general level of user costs are reduced implying a reduction in production costs for both sectors. Therefore, the instrument does not affect the allocation of capital and labor across sectors. It is clear that this subsidy is an indirect instrument, since it does not affect the distortion from monopoly pricing directly but instead distorts the capital market.

The investment subsidy has opposite effects on welfare. On the one hand, the government distorts the market for physical capital by increasing the overall incentive to invest. Hence, an investment subsidy does not correct for the misallocation of resources across sectors. On the other hand, the subsidy indirectly increases intermediate production through accumulation of physical capital. Consequently, the policy maker cannot imitate the command optimum using this instrument.

Government spending under the two subsidies equal

$$B_X = S_X ucX = S_X \frac{\alpha^{2(1+\alpha)} L'^{1-\varepsilon} K'^{\varepsilon}}{(1 - S_X)^{\alpha}}$$

when intermediate production is subsidized and

$$B_K = S_K \left( \dot{K} + \delta K \right)$$

when investments are subsidized. In the following, the analysis is performed under the assumption of a balanced government budget. The level of financial resources, $\overline{B}$, used to correct the imperfection of the economy is predetermined, implying that the two subsidy levels are determined by $\overline{B} = B_X = B_K$. It is common to analyze economic policy for unrestricted government spending. Hence, the government implements the subsidy level, and the required costs are determined accordingly. The approach taken in this analysis is opposite in the sense that the spending level is exogenous, implying that the subsidy rate is determined accordingly.

# 3 Welfare Analysis

## 3.1 Specific Factors Model

It is not possible to study the total welfare effect including the transitional dynamics between steady state equilibria analytically in the general version of the model. However, the version of the model with physical capital as specific production factor to intermediate production and labor as specific production factor to final goods production, i.e. $\xi = 1$ and $\beta = 0$, can be studied analytically. This version of the model is interesting in relation to subsidy levels because the two instruments have different implications for the required level of government spending. Hence, it has important implications for the costs required for implementing the two subsidies. It turns out that the investment subsidy is always more cost effective than the production subsidy. The specific factor version of the model is not interesting, however, in relation to comparing instruments by itself, because the investment subsidy essentially is equivalent to the production subsidy. As a consequence, it is not possible to distinguish the two instruments in the reduced form of the model. In other words, in terms of economic effects it does not matter whether the government uses an investment subsidy or a production subsidy of similar level.

Steady state consumption under the investment subsidy, i.e. $S_K > 0$ and $S_X = 0$, in relation to steady state consumption under the production subsidy, i.e. $S_K = 0$ and $S_X > 0$, equals:

$$\frac{C_K^*}{C_X^*} = \left(\frac{1 - S_X}{1 - S_K}\right)^{\frac{1}{1-\alpha}} \frac{(\delta + \rho)(1 - S_K) - \delta}{(\delta + \rho)(1 - S_X) - \delta}$$

where subscripts denote the applied policy instrument. $^*$ denotes the steady state value of a variable. The relative government spending required to implement the two subsidies equals:

$$\frac{B_K^*}{B_X^*} = \frac{S_K}{S_X}\left(\frac{1 - S_X}{1 - S_K}\right)^{\frac{1}{1-\alpha}} \frac{\delta}{\delta + \rho}.$$

It is easily seen that $C_K^*/C_X^* = 1$ and $B_K^*/B_X^* = \delta/(\delta + \rho) < 1$ for $S_K = S_X$. To ensure government spending of similar magnitudes under the two instruments, i.e. $B_K^*/B_X^* = 1$, $S_K$ has to increase and/or $S_X$ has to decrease, which implies that $C_K^*/C_X^* > 1$. Consequently, steady state consumption under the investment subsidy increases by more than steady state consumption under the production subsidy, leading to higher steady state welfare for the investment subsidy as long as the policy does not over-subsidize the activity.

In this version of the model, the investment subsidy generates no distortions in the sense that the shares of primary production factors employed in final goods production are too high. Since the investment subsidy does not distort the economy, we cannot distinguish between the economic effects of the two subsidies. In this sense, it is not important whether the government uses one instrument or the other. What is important, however, is that the government should use the investment subsidy because it is more cost effective. If the government can correct fully for the monopoly distortion it should use an investment subsidy of $S_K = 1 - \alpha$, which generates the optimum level of the physical capital stock.

It is not only in steady state equilibrium that the investment subsidy results in relatively low levels of government spending. The result holds when the transitional dynamics is taken into account because the solution of the model is the same under the two policy instruments, see Appendix $C.1$. Government spending, on the other hand, equals:

$$\begin{aligned} B_X &= \frac{S_X \alpha^{1+2\alpha} L'^{1-\varepsilon} K'^{\varepsilon}}{(1 - S_X)^{\alpha}} = S_X K (r + \delta) \\ B_K &= S_K K (g_K + \delta) \end{aligned}$$

under the two subsidies. It is seen that $B_X$ and $B_K$ depend on the same variables except for $B_K$ depending on the growth rate of capital and $B_X$ depending on the rate of return. Since the rate of return always exceeds the growth rate, which is easily verified by $g_K = r - (C + B) / ((1 - S_K) K) < r$, $B_X > B_K$ for $S_X = S_K$ always hold. Hence, for given subsidy levels the level of government spending under the production subsidy always exceeds that of the investment subsidy, implying that the investment subsidy is the first-best instrument for all levels of government spending.

## 3.2 Simulations of the Model

### 3.2.1 Specific Factor Model

Figure 1 shows the welfare effect of the two subsidies for different subsidy levels. The maximum steady state welfare is obtained for a subsidy level of $S_i = 0.5$ with $i = K, X$ in the base line scenario with parameter values equal to $\rho = 0.055$, $\theta = 2$, $\alpha = 0.5$, $\beta = 0$, $\xi = 1$, $\delta = 0.05$, and $L = 1$.

[Figure 1 about here]

It is evident that a given welfare effect is always achieved for lower financial resources when the investment subsidy is applied.

The main result of analyzing the specific factors version of the model is that the government should use an investment subsidy when it can choose between a production subsidy and an investment subsidy to correct directly for a monopoly distortion. In this version of the model, there is no differences between economic effects of the two subsidies, however, there is an important difference since the investment subsidy is more cost effective for all levels of financial resources. The broader insight of the result is that a government should identify the most cost effective alternative of direct instruments when government spending is restricted.

### 3.2.2 General Model

The result of the above section is the basis for the hypothesis that the investment subsidy, i.e. the indirect instrument, may lead to a higher welfare effect that the production subsidy, i.e. the direct subsidy, for certain cases of the general model under restricted government spending. This hypothesis is based on a trade-off between two opposite effects. On the one hand, the indirect instrument may be more cost effective implying that the subsidy level is possibly higher when the investment subsidy is used. This potentially leads to a larger effect on intermediate production. On the other hand, the investment subsidy distorts the capital market in the sense that the investment price and thereby user costs of physical capital are lowered, leading to higher demand for physical capital in both sectors of the economy. Consequently, the subsidy does not improve upon the misallocation of primary production factors across sectors. In the following, it is investigated if the former positive welfare effect from cost effectiveness can outweigh the latter negative welfare effect from introducing new distortions by such a magnitude that the government should use the indirect instrument to correct for monopoly prices under restricted government spending.

Government spending is assumed to equal 1% of initial value added, i.e. value added in the initial steady state equilibrium without government intervention.

[Figure 2 about here]

Figure 2 presents the adjustment of key economic variables over time. Panel *a* confirms that the level of the investment subsidy exceeds that of the production subsidy. This leads to a higher capital stock such that the investment subsidy brings the capital stock closer to the socially optimal level, see Panel *b*. On the other hand, the share of capital employed in the intermediate sector is not affected by the investment subsidy, whereas it is brought closer to the optimal value under the production subsidy, see Panel *c*. The investment subsidy does not affect the share of capital as a consequence of the distortion in the market for physical capital. Under the production subsidy, the government increases the relative incentive to produce in the intermediate sector, implying that larger shares of primary production factors are allocated to this sector.

The remaining panels present the effects of the two subsidies on consumption, the value of the monopoly, and the rate of return. The important question is whether the welfare effect of the investment subsidy is larger than that of the production subsidy. The time profiles of consumption hint to the answer, see Panel *d*. It is evident that the consumption level decreases on impact when a subsidy is implemented and increases over time to a new and higher level. Under the investment subsidy, the incentive to invest is increased, leading to a higher share of output invested in physical capital. This tends to lower consumption in the economy. Under the production subsidy larger shares of primary production factors are employed in intermediate production, which increases the demand for physical capital and thereby increases the level of investments. This effect depresses the level of output available for consumption. On the other hand, the higher level of production factors devoted to intermediate production and thereby higher intermediate output leads to an opposite effect on final goods output, which thereby increases the level of output available for consumption. For the parameter values used in the numerical simulation the net-effect of these changes implies a lower consumption level on impact. In the longer run, higher capital stocks kick in and increase consumption levels.

On impact, consumption decreases by about 2 percent under the investment subsidy, whereas it decreases by 0.6 percent only under the production subsidy. Over time consumption increases by as much as 6 percent under the investment subsidy and about 3 percent under the production subsidy. The issue of interest is whether the consumption profile of the investment subsidy leads to higher welfare than the production subsidy. This turns out to be the case; the change in equivalent variation of the investment subsidy equals 1.32%, whereas the change equals 1.13% for the production subsidy, see Appendix $E$ for the derivation of the equivalent variation. Hence, the indirect instrument leads to a welfare gain that is about one sixth larger than that of the direct instrument.

Figure 3, Panel $a$, presents the change in equivalent variations of the two subsidies for different levels of government spending in the base line scenario. It is seen that the indirect instrument generates a higher welfare effect for spending levels below 4 % of the initial output level, implying that the government should use the indirect instrument. Above this spending level, the government should use the direct instrument because it generates a larger welfare effect.

[Figure 3 about here]

Figure 3 is consistent with three propositions developed in Bhagwati (1971). The first proposition states that "optimal policy intervention, in the presence of distortions, involves a tax-cum-subsidy policy addressed directly to offsetting the source of the distortions..". The second proposition states that "for each distortion .. it is possible to analyze the welfare ranking of all alternative policies, from the (first-best) optimal to the second-best ..". Finally, the third proposition states that "reductions in the "degree" of an only distortion are successively welfare increasing until the distortion is fully eliminated". The present analysis complements these propositions with the result that there may exist alternative instruments to the direct instrument that leads to higher welfare increases for "high degrees" of an only distortion.

For the remaining panels, the sensitivity to changes in the parameter values of the result in Panel $a$ is investigated. Panels $e$ and $f$ present the sensitivity from changes in $\xi$ and $\beta$. These two parameters represent the importance of physical capital as production factor in intermediate goods production and in final goods production, respectively. The more important physical capital is in intermediate production, i.e. the higher is $\xi$, the higher is the cost effectiveness of the investment subsidy and the higher is the relative change in the equivalent variation. The reason is that an increase in $\xi$ implies that the investment subsidy has a larger effect on intermediate production. For the same reason, the equivalent variation related to the production subsidy also increases. However, the positive effect on the equivalent variation for the investment subsidy exceeds that of the production subsidy, leading to higher relative equivalent variation. On the contrary, the more important physical capital is in final goods production, i.e. the higher is $\beta$, the higher is the welfare loss from introducing additional distortions under the investment subsidy and the lower is the relative equivalent variation. This implies that the production subsidy becomes more advantageous to apply.

### 3.2.3 Combined Policies

A final issue is whether it is preferable for the government to use either the investment subsidy or the production subsidy separately or whether policies combining the two subsidies should rather be used. Welfare effects of combined policies are presented in Figure 4.

[Figure 4 about here]

The value on the horizontal axis shows the share of government spending used on the investment subsidy. The remaining share is used on the production subsidy. The change in the equivalent variation of different policies is measured in relation to the change for the production subsidy only policy. It is evident that the investment subsidy only is the optimal policy when government spending is 1 or 2 percent of initial output. When government spending equals 3, 4 or 10 percent, a combined policy is preferred, whereas the production subsidy only is the optimal policy when government spending equals 15 percent of initial output.

It is found that the threshold level of government spending for a combined policy to be preferred to a production subsidy only policy equals 13 percent of initial output. This should be compared to the requirement for government spending under the optimum policy, which equals 21 percent of initial output in the base line scenario. Consequently, for levels of government spending below 60 percent of the spending level required for the optimum policy, investment and production subsidies should be used in combination.

The main insight from Figure 4 is that the importance of the investment subsidy in designing economic policy is phased out continuously when the level of government spending is increased. When this level increases, both subsidies increase for unchanged expenditure shares used on the two subsidies. This generates two effects. First, the higher investment subsidy results in a more severe effect on welfare from the new distortion introduced in the market for physical capital. Second, the higher production subsidy indirectly increases the incentive to invest as discussed above in Section 2.5. Both effects tend to lower the investment subsidy, such that the new combined policy consists of a lower expenditure share for the investment subsidy.

# 4 Discussion and Conclusion

Bhagwati (1971) generalizes the insight from Bhagwati and Ramaswami (1963) and derives three important results in the case of an only market distortion: The first proposition states that "optimal policy intervention, in the presence of distortions, involves a tax-cum-subsidy policy addressed directly to offsetting the source of the distortions..". The second proposition states that "for each distortion .. it is possible to analyze the welfare ranking of all alternative policies, from the (first-best) optimal to the second-best ..". Finally, the third proposition states that "reductions in the "degree" of an only distortion are successively welfare increasing until the distortion is fully eliminated".

The results of Bhagwati (1971) leave room for an important hypothesis: In the situation with indirect dynamic distortions and restricted government spending it may be the case that policy instruments targeted at the indirect dynamic distortions lead to higher welfare effects than the direct instrument. This hypothesis is supported in the present paper and may be the case if the indirect instrument is more cost effective than the direct instrument. This implies a positive relative welfare effect that may be so large that it is not outweighed by negative welfare effects from introducing new distortions in the economy. Hence, it may be the case that an instrument used to correct for the indirect dynamic distortion leads to a higher welfare effect for lower levels of government spending, even though welfare increases continuously with the direct instrument.

Sriniswasan (1996) discusses the results of Bhagwati (1971) and concludes that the main insight is still valid. In the economic literature the original framework has been extended to include analyses performed in dynamic settings. In this relation, Bark (1987) analyzes welfare under autarky and under free trade when distortions are present. The main result of the analysis is that free trade may be inferior to autarky when distortions cannot be removed. Moreover, an important line of research related to credibility and time inconsistency of trade policy exists, see for example Rodrik (1989, 1992). To my knowledge no study addresses the question investigated in the present analysis.

There are two broader implications of the analysis presented in this paper. First, the policy instruments that are appropriate to implement depend on the government tax base. This may be also be relevant for other applications. One such example is R&D policies motivated by knowledge spillovers. Most developed countries have R&D expenditures as a share of GDP around 2-2.5 % with governments spending around one third to one half of total R&D expenditures, implying that government spending is around 0.5-1 % of GDP, see OECD (2004). Jones and Williams (1998) argue that such spillovers are important and that the optimal level of R&D expenditures are at least four times higher than the actual level for the U.S. economy suggesting that more government spending should be targeted on the activity. Mohnen (1996) argues that the social rate of return to R&D shows great dispersion across industries and estimated spillovers can be negative. Hence, it is not clear that R&D policies are targeted on the right activities. An informed guess based on the main result of this paper, however, is that R&D subsidies may be appropriate to use from a welfare perspective even when knowledge spillovers are absent because they are targeted on investment incentives.

Another important implication is that a wide range of policy instruments should be included when economic effects of policy programs are analyzed for restricted government spending. The result is especially important in relation to economies on relatively low stages of development that receive development aid from foreign donors. Such foreign transfers are relatively low relative to GDP in receiving countries, see for example Burnside and Dollar (2000). The present paper suggests that support could appropriately be used directly to encourage investment incentives instead of using instruments that do not affect these incentives directly, including direct instruments that has static effects because of larger welfare effects.

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# A Solving the Production Side

The production side of the economy can be formulated in six equations in reduced form. These are the expressions for the rate of return, the wage rate, and inputs of primary production factors in the two sectors. The rate of return and the wage rate equal:

$$r = \alpha^2 \left( \frac{\alpha^2 (1-\xi) + 1 - \alpha - \beta}{\alpha^2 \xi + \beta} \frac{K}{L} \right)^{-(1-\alpha\xi-\beta)} - \delta \tag{14}$$

$$w = \alpha^2 \left( \frac{\alpha^2 (1-\xi) + 1 - \alpha - \beta}{\alpha^2 \xi + \beta} \frac{K}{L} \right)^{\alpha\xi+\beta}, \tag{15}$$

whereas inputs of primary production factors equal

$$K_Y = \frac{\beta}{\alpha^2 \xi + \beta} K \tag{16}$$

and

$$L_Y = \frac{\alpha^2 \xi + \beta}{\alpha^2 (1-\xi) + 1 - \alpha - \beta} L. \tag{17}$$

$K_X$ and $L_X$ are determined by $K_X = K - K_Y$ and $L_X = L - L_Y$. All expressions depend on aggregate physical capital and exogenous parameters.

# B Market Clearing Condition

The market clearing condition for final goods is derived from (10) using the definition for financial capital:

$$F = K + p_N$$

where $p_N$ is the value of the intermediate monopoly that equals the present value of profit in the intermediate sector, i.e.

$$p_N = \int_t^\infty \exp\left( - \int_t^\tau r_v dv \right) \pi_\tau d\tau.$$

This expression is used to derive

$$r p_N = \dot{p}_N + \pi. \tag{18}$$

(10) is rewritten to:

$$\dot{K} = r_K K + \pi + wL - C - \delta K$$

using (18) and $rF = r_K K + rp_N - \delta K$. Profit and labor income are rewritten to:

$$\pi = \frac{1-\alpha}{\alpha}\alpha^{2(1+\alpha)} K'^{\varepsilon} L'^{(1-\varepsilon)},$$
$$wL = \alpha^{2\alpha} \left(K'/L'\right)^{\varepsilon} L,$$

using (8) and (15), whereas the return to capital is rewritten to

$$\left(r_K - \delta\right) K = \alpha^{2\alpha} \left(K'/L'\right)^{(1-\varepsilon)} K - \delta K.$$

using (14). Substituting these expressions into the above equation for $\dot{K}$ leads to (12) of the main text.

# C The Solution to the Model

The solution to the model is given by equations (14), (15), (16), (17), (11), (12), (18) and the transversality condition $\lim_{t\to\infty} \left[a\left(t\right) F\left(t\right)\right] = 0$, where $a\left(t\right)$ is the co-state variable associated with the stock of financial assets. After implementation of the production subsidy, the equilibrium equals:

$$\begin{aligned}
\dot{K} &= a^{2\alpha} K'^{\varepsilon} L'^{1-\varepsilon} \frac{1-\left(1-\alpha\right) S_X}{\left(1-S_X\right)^{\alpha}} - C - B - \delta K \qquad (19)\\
\dot{C} &= \left(r-\rho\right) C/\rho \\
\dot{P}_N &= \left(rP_N - \frac{\left(1-\alpha\right)}{\alpha}\alpha^{2(1+\alpha)} \left(1-S_X\right)^{-\alpha} K'^{\varepsilon} L'^{1-\varepsilon}\right)
\end{aligned}$$

where

$$r = \frac{a^{2\alpha}\left(K'/L'\right)^{-(1-\varepsilon)}}{\left(1-S_X\right)^{\alpha}} - \delta$$

and

$$\begin{aligned}
K' &= K/\left(\left(1-S_X\right)\beta + \alpha^2\xi\right)\\
L' &= L/\left(\left(1-S_X\right)\left(1-\alpha-\beta\right) + \alpha^2\left(1-\xi\right)\right)\\
\varepsilon &= \alpha\xi + \beta
\end{aligned}$$

$B$ indicates government spending, which is determined as a given value, i.e. $B = \overline{B}$. Under the production subsidy, government spending equals

$$B = S_X ucX = \frac{S_X\alpha^{2(1+\alpha)}}{\left(1-S_X\right)^{\alpha}} K'^{\varepsilon} L'^{1-\varepsilon}.$$

Under the investment subsidy, an additional differential equation for $S_K$ is introduced. The system equals

$$\begin{aligned}
\dot{K} &= \frac{a^{2\alpha} K'^{\varepsilon} L'^{1-\varepsilon}}{(1-S_K)} - \frac{C+B}{(1-S_K)} - \delta K \qquad (20) \\
\dot{C} &= (r-\rho)\, C/\rho \\
\dot{P}_N &= \left( r P_N - \frac{(1-\alpha)}{\alpha} \alpha^{2(1+\alpha)} K'^{\varepsilon} L'^{1-\varepsilon} \right) \\
(1 - \overset{\bullet}{S_K}) &= (1-S_K)(r+\delta) - \alpha^{2\alpha} (L'/K')^{1-\varepsilon}
\end{aligned}$$

where

$$r = \frac{a^{2\alpha} (K'/L')^{-(1-\varepsilon)}}{(1-S_K)} - \delta$$

and $K'$, $L'$ and $\varepsilon$ are determined as above with $S_X = 0$. Under the investment subsidy, government spending equals

$$B = S_K \left( \dot{K} + \delta K \right).$$

## C.1 Specific Factor Model

The specific factor model, i.e. $\xi = 1$ and $\beta = 0$, equals:

$$\begin{aligned}
\dot{K} &= \frac{L^{1-\alpha} K^{\alpha}}{(1-\alpha)^{1-\alpha}} - C - \delta K \\
\dot{C} &= \left( \frac{\alpha^2 (L/K)^{1-\alpha}}{(1-\alpha)^{1-\alpha} (1-S_i)} - \delta - \rho \right) \frac{C}{\theta} \\
\dot{P} &= \frac{\alpha^2 (L/K)^{1-\alpha}}{(1-\alpha)^{1-\alpha} (1-S_i)} \left( P - \frac{1-\alpha}{\alpha} (1-S_i) K \right) - \delta P
\end{aligned}$$

where $i = (X, K)$. It is evident that the economic effects are invariant to the chosen policy instrument.

## C.2 Steady-State Equilibrium

Using the two systems (19) and (20), the steady state values for $C$ and $K$ are derived under the two policy instruments. The steady state values for consumption equal

$$\begin{aligned}
C_K^* &= (1-S_K^*)\left(\frac{\delta+\rho}{\beta+\alpha^2\xi}-\delta\right)K^*-B_K \\
C_X^* &= \left(\frac{(\delta+\rho)\left(1-S_X^*\left(1-\alpha\right)\right)}{\left(1-S_X\right)\beta+\alpha^2\xi}-\delta\right)K_X^*-B_X
\end{aligned}$$

$^*$ denotes the steady state value of a variable. Steady state values of $K$ are presented below.

# D Market Solution and Command Optimum

The shares of primary production factors, the rate of return in relation to the wage rate and the steady state capital stock equal:

$$\begin{aligned}
K_Y^M/K_X^M &= \left(1-S_X\right)\beta/\left(\alpha^2\xi\right) \\
L_Y^M/L_X^M &= \left(1-S_X\right)\left(1-\alpha-\beta\right)/\left(\alpha^2\left(1-\xi\right)\right) \\
\frac{r_K^M}{w^M} &= \frac{\alpha^2\xi+\left(1-S_X\right)\beta}{\alpha^2\left(1-\xi\right)+\left(1-S_X\right)\left(1-\alpha-\beta\right)}\frac{L}{K} \\
K^{M^*} &= \left(\frac{\alpha^{2\alpha}}{\left(\delta+\rho\right)\left(1-S_X\right)^{\alpha}\left(1-S_K\right)}\right)^{\frac{1}{1-\varepsilon}}\left(\left(1-S_X\right)\beta+\alpha^2\xi\right)L'
\end{aligned}$$

after implementation of the two subsidies. $^*$ denotes the steady state value of a variable. The laissez-faire solution of the model is derive for $S_X = S_K = 0$.

For comparison, the command optimum is presented. In the planned economy, i.e. in the absence of the monopoly distortion, the equilibrium equals:

$$\begin{aligned}
K_Y^C/K_X^C &= \beta/\left(\alpha\xi\right) \\
L_Y^C/L_X^C &= \left(1-\alpha-\beta\right)/\left(\alpha\left(1-\xi\right)\right) \\
\frac{r_K^C+\delta}{w^C} &= \frac{\alpha\xi+\beta}{1-\alpha\xi-\beta}\frac{L}{K} \\
K^{C^*} &= \left(\frac{\alpha^{\alpha}}{\delta+\rho}\right)^{\frac{1}{1-\varepsilon}}\frac{\beta+\alpha\xi}{1-\alpha\xi-\beta}L
\end{aligned}$$

# E Dynamic Equivalent Variation

The intertemporal budget constraint:

$$\int_0^\infty \exp\left(-\int_0^t r_v dv\right) C_t dt = H_0 + F_0 - B_0'$$

is used with the Euler condition for consumption to express:

$$C_0 = \frac{1}{\Omega_0}\left(H_0 + F_0 - B_0'\right)$$

where

$$H_0 = \int_0^\infty w_t L_t \exp\left(-\int_0^t r_v dv\right) dt$$

$$F_0 = P_{K_0} K_0 + P_{N_0}$$

and

$$B_0' = B_0 \int_0^\infty \exp\left(-\int_0^t r_v dv\right) dt.$$

$H_0$ is the present value of labor income, $F_0$ is non-human wealth at time 0, and $B_0'$ is the present value of tax payments.

$$\Omega_0 = \int_0^\infty \exp\left(\int_0^t \frac{(1-\theta) r_v - \rho}{\theta} dv\right) dt$$

By using the expression for $C_0$ and the Euler condition for consumption, the utility integral, the indirect intertemporal utility function can be formulated as:

$$U = \left(\Omega_0^\theta \left(H_0 + F_0 - B_0'\right)^{1-\theta} - \frac{1}{\rho}\right) / (1-\theta).$$

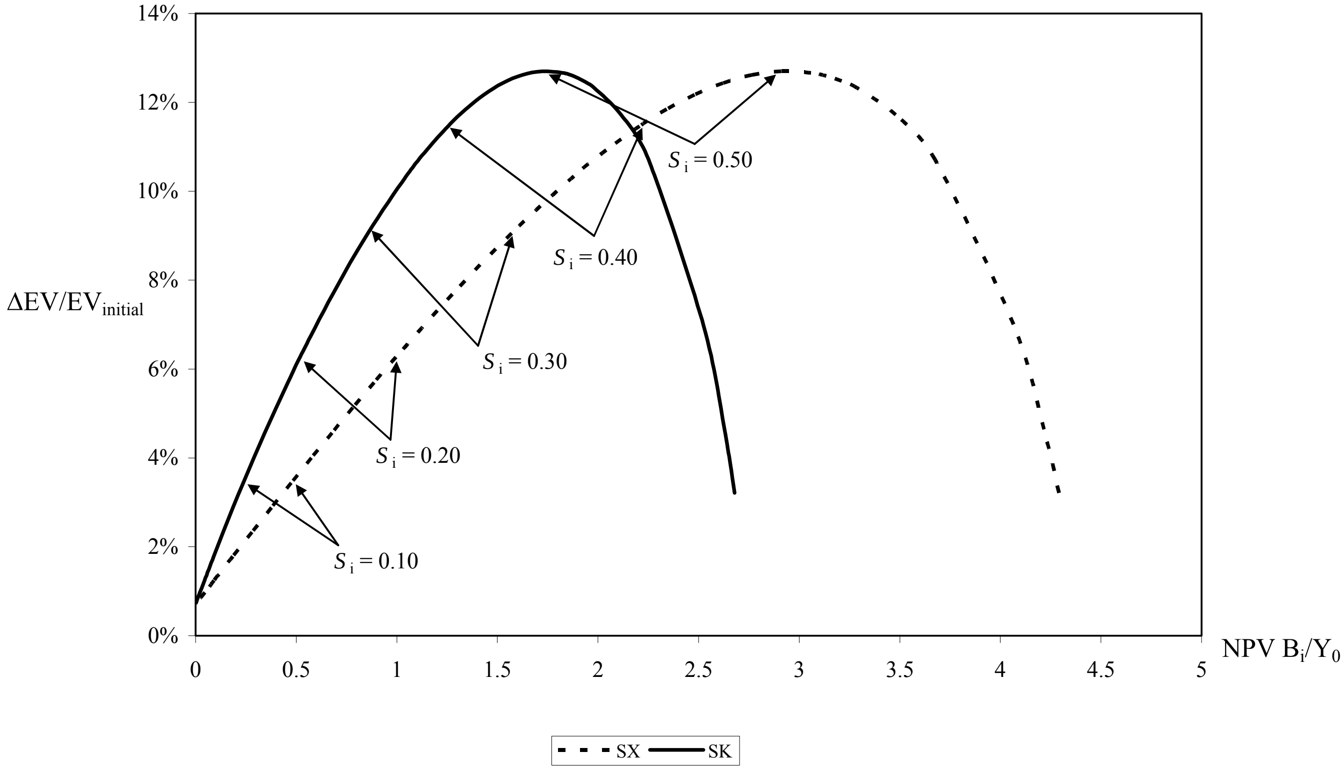
The dynamic equivalent variation is defined as follows:

$$\begin{aligned} & \left(\left(\Omega_0^M\right)^\theta \left(H_0^M + F_0^M + EV\right)^{1-\theta} - \frac{1}{\rho}\right) / (1-\theta) \\ = & \left(\left(\Omega_0^S\right)^\theta \left(H_0^S + F_0^S - B_0'^S\right)^{1-\theta} - \frac{1}{\rho}\right) / (1-\theta). \end{aligned}$$

The superscript $S$ denotes the case when a subsidy is implemented. $M$ denotes the initial situation described by laissez-faire steady-state equilibrium. This yields the equivalent variation:

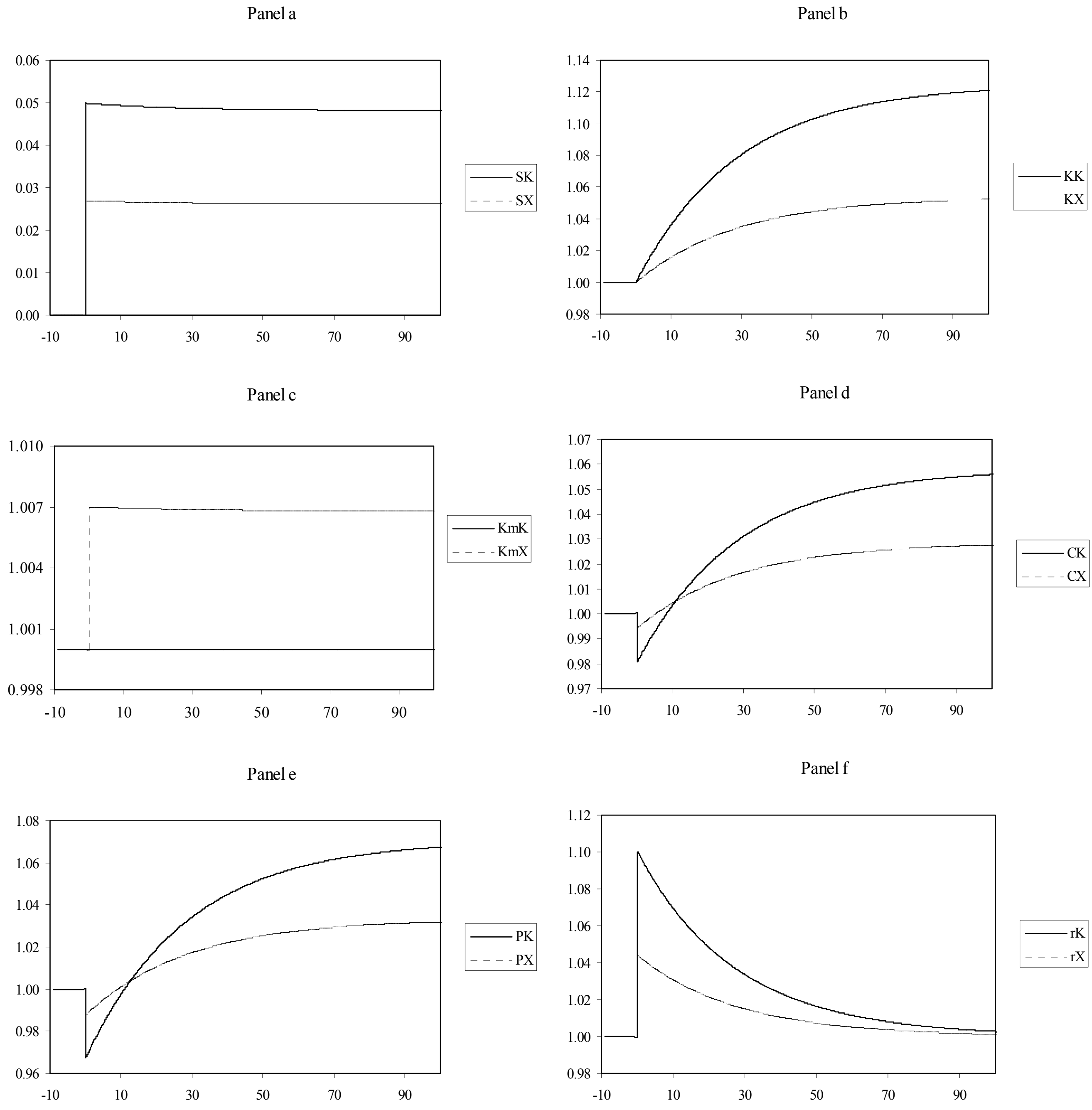
$$EV = \left(\frac{\Omega_0^S}{\Omega_0^M}\right)^{\theta/(1-\theta)} \left(H_0^S + F_0^S - B_0'^S\right) - \left(H_0^M + F_0^M\right)$$

**Figure 1**: Welfare Effects under Different Levels of Government Spending, Specific Factors Model.



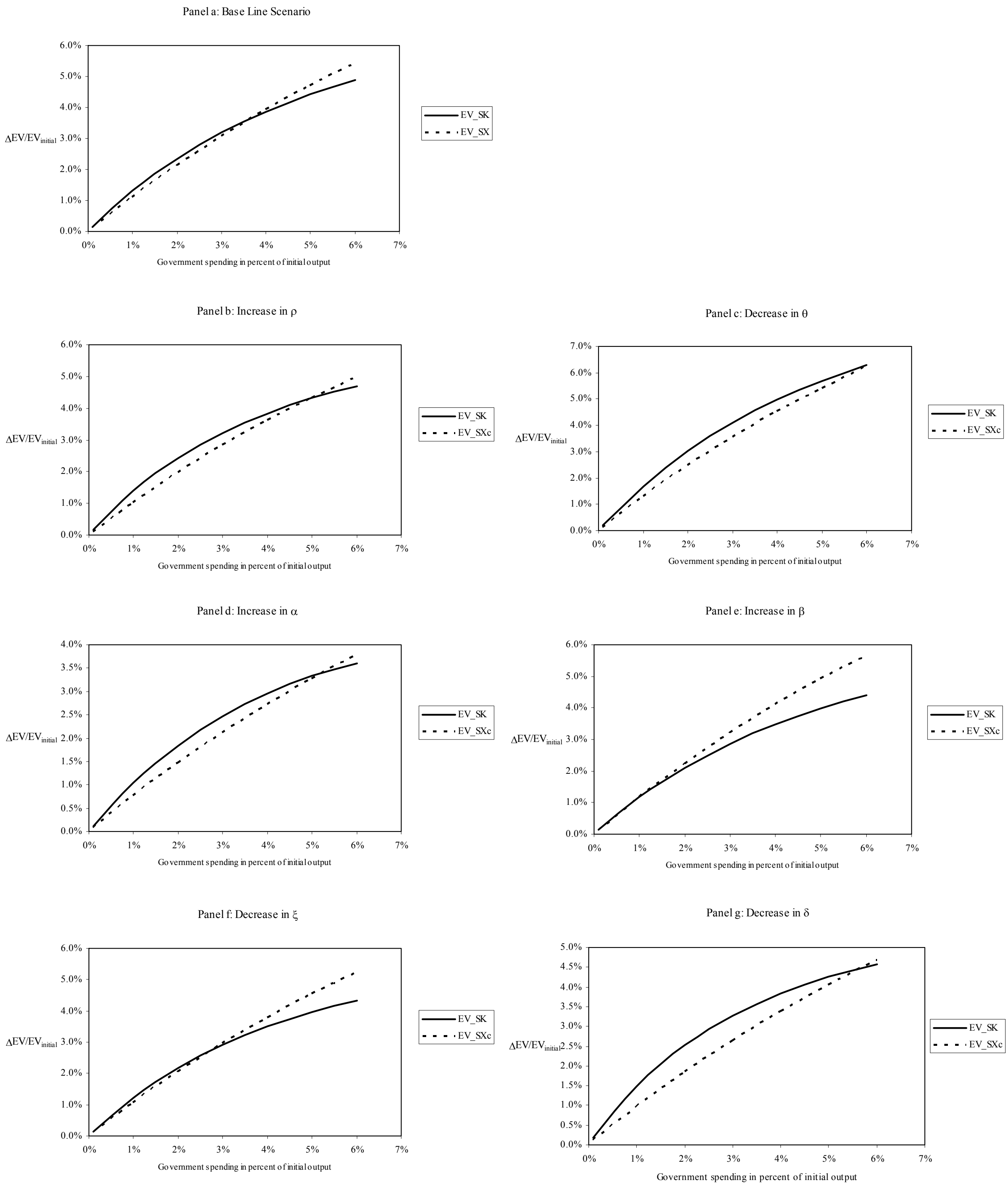

Note: To determine the welfare effects taking the transitional dynamics into account under the two policy instruments, the model is simulated using the "Time-Elimination Method", see Mulligan and Sala-i-Martin (1991 and 1993). Furthermore, the dynamic equivalent variation, EV, is applied to measure welfare effects. For a derivation of EV, see Appendix *E*. The transitional dynamics under the two subsidies are based on the parameter values $\rho$=0.055, $\theta$=2, $\alpha$=0.5, $\beta$=0, $\xi$=1, $\delta$=0.05 and L=1.

**Figure 2**: Transitional Dynamics, Base Line Scenario.



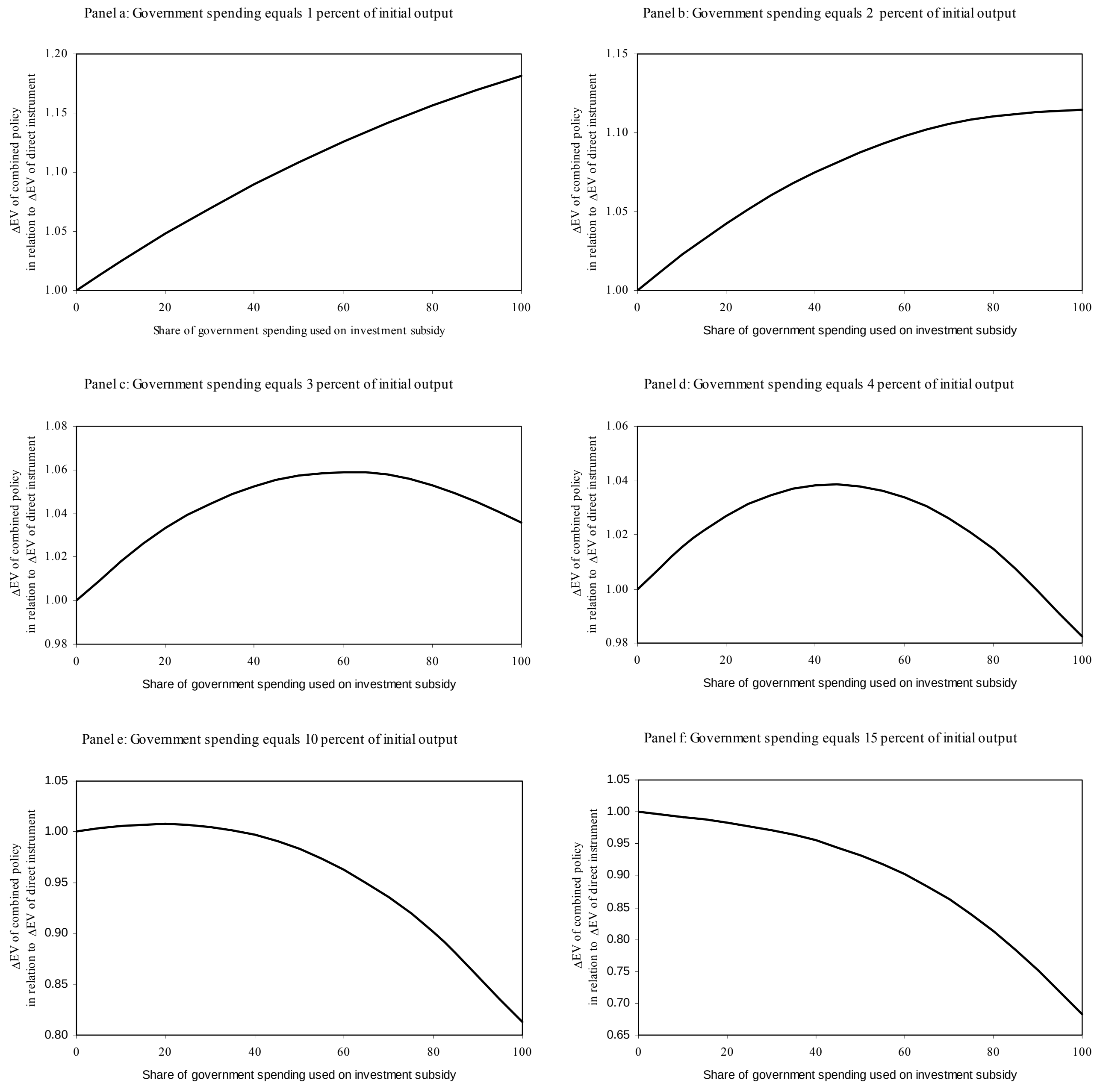

Note: To determine the transitional dynamics under the two policy instruments, the model is simulated using the "Time-Elimination Method", see Mulligan and Sala-i-Martin (1991 and 1993). The transitional dynamics under the two subsidies are presented for the base line scenario with parameter values $\rho$=0.055, $\theta$=2, $\alpha$=0.5, $\beta$=0.1, $\xi$=0.8, $\delta$=0.05 and L=1. The baseline parameters are chosen in line with existing literature on economic growth, see for example Mulligan and Sala-i-Martin (1993) and Barro and Sala-i-Martin (1995, Chapter 5).

**Figure 3**: Welfare Effects under Different Levels of Government Spending, General Model




Note: To determine the welfare effects taking the transitional dynamics into account under the two policy instruments, the model is simulated using the "Time-Elimination Method", see Mulligan and Sala-i-Martin (1991 and 1993). Furthermore, the dynamic equivalent variation, EV, is applied to measure welfare effects. For a derivation of EV, see Appendix *E*. In Panel a, parameter values equal $\rho$=0.055, $\theta$=2, $\alpha$=0.5, $\beta$=0.1, $\gamma$=0.8, $\delta$=0.05 and L=1. In Panel b, $\rho$ is increased to 0.08; in Panel c, $\theta$ is decreased to 1.001; in Panel d, $\alpha$ is increased to 0.6; in Panel e, $\beta$ is increased to 0.15; in Panel f, $\xi$ is decreased to 0.7; and, finally, in Panel g, $\delta$ is decreased to 0.025.

**Figure 4**: Welfare Effects of Combined Policies under Different Levels of Government Spending, General Model




Note: To determine the welfare effects taking the transitional dynamics into account under the two policy instruments, the model is simulated using the "Time-Elimination Method", see Mulligan and Sala-i-Martin (1991 and 1993). Furthermore, the dynamic equivalent variation, EV, is applied to measure welfare effects. For a derivation of EV, see Appendix *E*. Parameter values equal $\rho$=0.055, $\theta$=2, $\alpha$=0.5, $\beta$=0.1, $\gamma$=0.8, $\delta$=0.05 and L=1.