Danmarks Statistik
MODELGRUPPEN

Arbejdspapir

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Incorporating supply effects in ADAM's export equations

Resumé:

The working paper DSI080816 using a gravity equation provides empirical support for supply effects in the determination of Danish exports. The current paper shows how the estimated supply effects can be incorporated in the export relations in the current model version Okt16. The supply effect captures the effect on exports that arises from domestic output growth that is basically driven by changes in productivity and labor force, regardless of changes in the terms of trade. We compare the multiplier properties of Okt16-model with and without supply effects. The multiplier responses to a labor supply shock indicate that the short-term effect on output, exports and employment is larger when supply effects are included in exports. The long-term effect on wages is smaller as exports can increase without a need for declining terms of trade, this is also reflected on the long term effect on consumption that is zero.

[Preliminary version]

DSI111116

Nøgleord: export equations, supply effects, multiplier analysis

1. Background

The standard export relation in ADAM relates exports to relative prices and a measure for demand. The working paper (Temere and Kristensen, 2016, *DSI080816)* provided a motivation for including an additional explanatory variable that captures supply effects in the determination of exports, which is based on the seminal work of Krugman (1989). The main argument for supply effects is the observation that a country with a favorable domestic output growth can expand its share of the world market without a need for a decline in the terms of trade. An economy with increasing labor force and productivity can produce different varieties of a product thereby shifting the demand curve for its products outward. The standard export equation requires a secular decline in the terms of trade to explain the twin rise in output and exports; hence it might be missing out an important explanatory variable that quantifies supply effects, cf. *DSI080816* for more.

The primary objective of this paper is to provide a link on how the estimated supply effects from a gravity equation in *DSI080816* can be incorporated in ADAM's export relations. The paper also demonstrates the multiplier properties of ADAM with and without supply effects in exports using the current model version – Okt16.

The gravity equation used for estimation is written as:

$$E_{jt} = \frac{Y_t^{\theta} Y_{jt}^{\varphi}}{D_j^{\tau}} \qquad (1)$$

E_{jt} is value of Danish exports to partner-*j*, Y_t is Danish GDP in current prices, Y_{jt} is partner *j*'s GDP in current prices and D_j is physical distance between Denmark and partner-*j*. The parameters θ and φ measure, respectively, supply and demand effects. In practice (1) is augmented with a number of control dummies. We can re-write (1) so that it is an equation for market share.

$$\frac{E_{jt}}{Y_{jt}} = Y_t^{\theta} Y_{jt}^{\varphi-1} D_j^{-\tau} \qquad (2)$$

Equation (2) implies that if domestic output Y_t grows by 1 percent the market share, E_{jt}/Y_{jt}, grows by θ percent, which we call supply effects on exports.

On the other hand, the long-term market share equation in ADAM is given as:

$$\frac{fE_{jt}}{fEe_{jt}} = \left(\frac{pe_{jt}}{pee_{jt}}\right)^{-\beta} \qquad (3)$$

Equation (3) relates exports to demand measured by imports of partner-*j* fEe_j and export prices to partner-*j* pe_j measured relative to import prices of partner-*j* pee_j.[1] The distance variable measures costs such as transportation costs and

[1]In ADAM, partner's imports, fEe_j, and their import prices, pee_j, are used instead of GDP, fY_j, and its deflator, py_j, for two main reasons. First, GDP is a broad measure for demand, a growth in a particular partner's GDP driven by domestic factors need not necessarily affect Danish

since *c.i.f* import prices incorporate shipping costs, equation (3) can be estimated without a distance variable.

Equation (2) explicitly includes supply effects, but in equation (3) it is present only implicitly. This is because as the supply of Danish exports increase due to say expansion in productivity at home, partners' import from Denmark increases that is part of fEe_j. So if we want to measure the marginal supply effect on Danish market share, we need to augment equation (3) with a term for supply effects as in equation (2). Then we can re-write the long term relation (3) transformed in error correction form and augmented with the supply effect from (2) as:

$$\begin{aligned}\mathrm{Dlog}(fE_t) = {} & \Gamma_1 \mathrm{Dlog}(fEe_t) + \Gamma_2\, \mathrm{Dlog}\left(\frac{pe_t}{pee_t}\right) \\ & -\gamma\left[\log\left(\frac{fE_{t-1}}{fEe_{t-1}}\right) + \beta \log\left(\frac{pe_{t-1}}{pee_{t-1}}\right) - \theta \log(Y_t)\right] \\ & + k + \epsilon_t \end{aligned} \tag{4}$$

In standard-ADAM the supply elasticity θ is zero, i.e. no supply effect on exports.

The literature uses various measures to capture long-term growths in output and hence the corresponding supply effect on exports, such as manufacturing capacity, ratio of home to foreign productive capital stock, potential output growth of the exporting country, cf. *DSI080816* for more. Long term growth of a country is basically attributed to expansion in labor force (workers or hours worked) and productivity growth, and the long-term properties of ADAM reflects this, cf. Danmarks Statistik (2013). Thus, it makes sense to relate long-term growth in output to labor input that is defined in terms of efficiency corrected labor hours, i.e.

$$\begin{aligned}\mathrm{Dlog}(fE_t) = {} & \Gamma_1 \mathrm{Dlog}(fEe_t) + \Gamma_2\, \mathrm{Dlog}\left(\frac{pe_t}{pee_t}\right) \\ & -\gamma\left[\log\left(\frac{fE_{t-1}}{fEe_{t-1}}\right) + \beta \log\left(\frac{pe_{t-1}}{pee_{t-1}}\right) - \theta \log\left(\frac{Q_t \cdot Hg_t \cdot kqyf_t}{Q_t^0 \cdot Hg_t^0 \cdot kqyf_t^0}\right)\right] \\ & + k + \epsilon_t \end{aligned} \tag{4*}$$

Where Q_t is number of workers, Hg_t is annual working hours per employed and $kqyf_t$ is hourly productivity measured as the ratio between gross value added and total hours worked; the product $Q_t \cdot Hg_t \cdot kqyf_t$ represents the

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exports. Whereas, imports can be more directly related with demand for Danish goods. Second, it is connected with globalization and the international division of labor it brought. The equation for import shares in ADAM, besides relative prices, includes a logistic trend that is concave downward. The logistic trend captures the strong growth in import market shares in the beginning of the 1970s due to the increasing international division of labor. In recent years, the logistic trend has lost significance, which implies import shares are more consistent with relative prices. The export equations do not include a logistic trend, using imports as a measure for demand account for the international division of labor that affects exports through the export markets.

efficiency corrected labor hours; $Q_t^0 \cdot Hg_t^0 \cdot kqyf_t^0$ represents the baseline solution to the efficiency corrected labor hours. The parameter θ is set to 0.7, based on the gravity equation estimated in *DSI080816*.

The intuition behind (4*) is that whenever the actual efficiency corrected labor input deviates from its steady-state path, there will be a long-term expansion in output and thus growth in exports with a supply elasticity of 0.7 that is not necessarily due to changes in price competitiveness or changes in foreign demand. Equation (4*) is set up in ADAM in a way such that a user can choose to activate the supply effects with a switch dummy. In the following section, we demonstrate the multiplier responses of ADAM with and without supply effects.

2. Multiplier exercise

(A) Permanent increase in labor supply

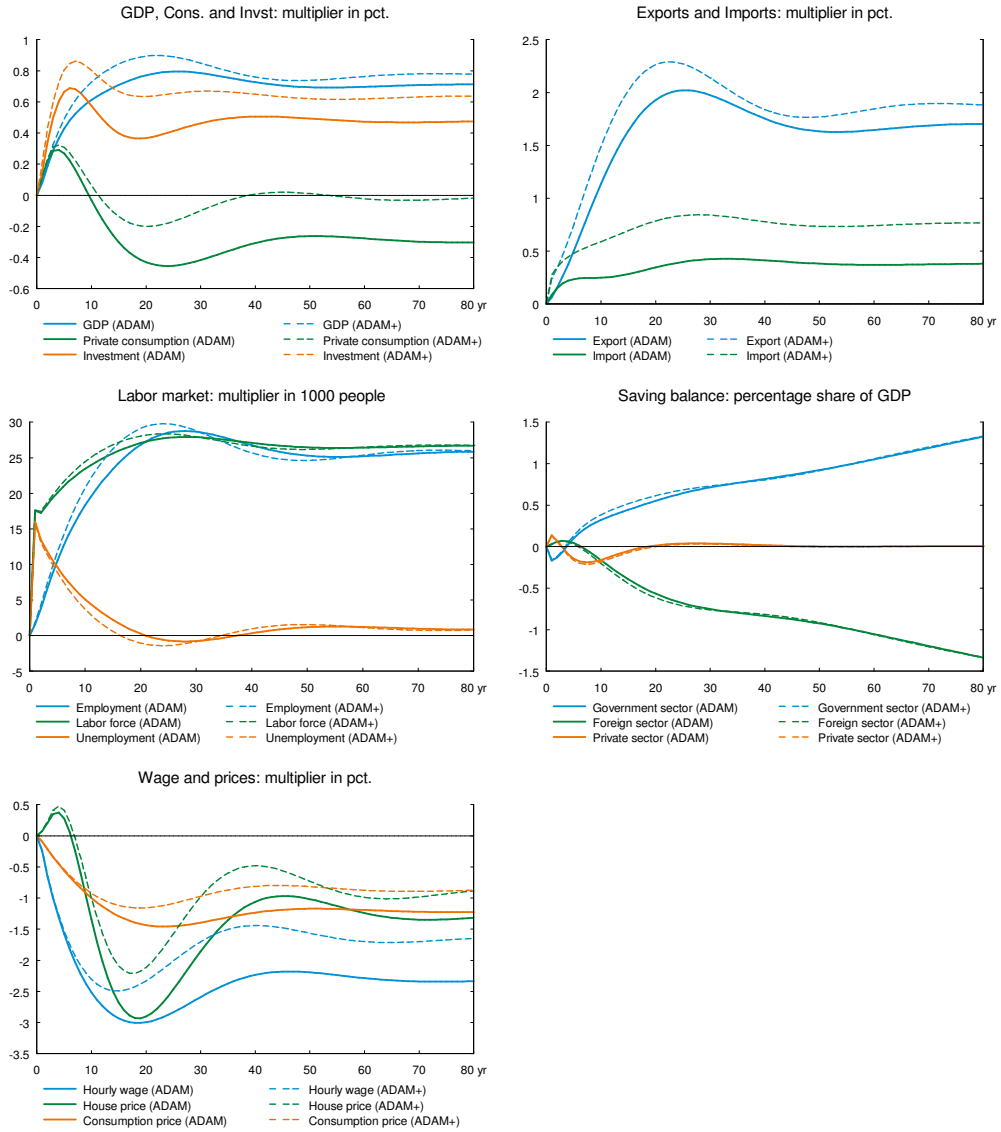
Figure 1 shows the effect of a permanent increase in labor supply. The expansion in labor supply is achieved by reducing the number of people outside the labor force not receiving transfers by 1 percent of the total employment.

The permanent increase in labor force initially increases unemployment, which is later soaked up when production and exports begin to expand. Production expands because the initial increase in unemployment puts a downward pressure on wage growth that improves competitiveness leading to higher exports and production. Gradually, the additional labor force gets fully employed, which makes production and employment increase permanently. The short term effect on exports is higher when supply factors directly enter the determination of exports, because now exports can increase without the need for changes in price competitiveness. The fall in wages is also smaller when supply factors are active, because now the necessary change in exports can be achieved without a significant fall in wages. The long-term negative effect on consumption in the standard case disappears when exports respond to supply effects. The additional labor force creates a positive effect on public saving, and the effect is not sensitive to the supply effect.

The export relation with supply effects can be compared with an export relation with large export price elasticities and no supply effects.[2] With large export price elasticities, wages need to fall by a proportionately lower amount to improve competitiveness and raise exports. Figure A1 in the appendix compares the multiplier properties of ADAM with supply effects and large export price elasticities. It is shown that a 40 percent increase in the export price elasticities is roughly enough to explain the response in exports with a supply elasticity of $\theta = 0.7$, albeit with some differences in the dynamics.

[2]Such a comparison is not guaranteed if the experiments, for instance, involve demand side shocks.

Figure 1. The effect of a permanent increase in labor supply, 1% of employment

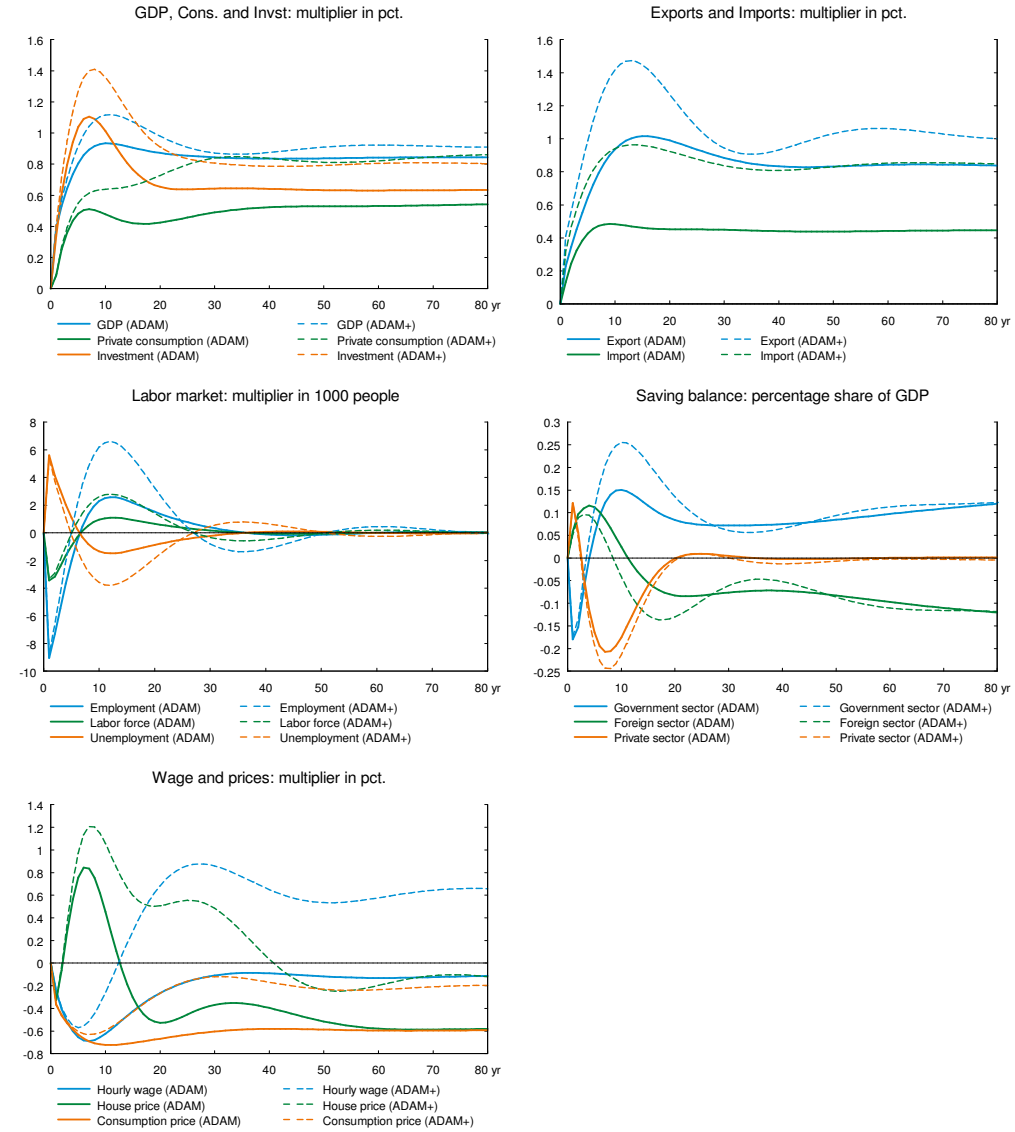


NOTE: Solid lines represent standard-ADAM with no supply effects (**ADAM**), i.e. $\theta = 0$ in equation (4*); and stippled lines represent ADAM with supply effects (**ADAM+**), i.e. $\theta = 0.7$ in equation (4*).

(B) Permanent increase in labor productivity

Increased productivity means more output for the same level of input, which potentially leads to more exports. Figure 2 shows the effect of a permeant increase in labor productivity. Unemployment increases immediately as the same amount of output can now be produced with fewer labor input. Wages fall and kick start a wage driven adjustment process eventually returning unemployment back to equilibrium. Output and export rise more with supply effects, the corresponding fall in wages is also smaller, which is basically the same as the reactions in the labor supply experiment above.

Figure 2. The effect of a permanent 1% increase in labor productivity



NOTE: Solid lines represent standard-ADAM with no supply effects (**ADAM**), i.e. $\theta = 0$ in equation (4*); and stippled lines represent ADAM with supply effects (**ADAM+**), i.e. $\theta = 0.7$ in equation (4*).

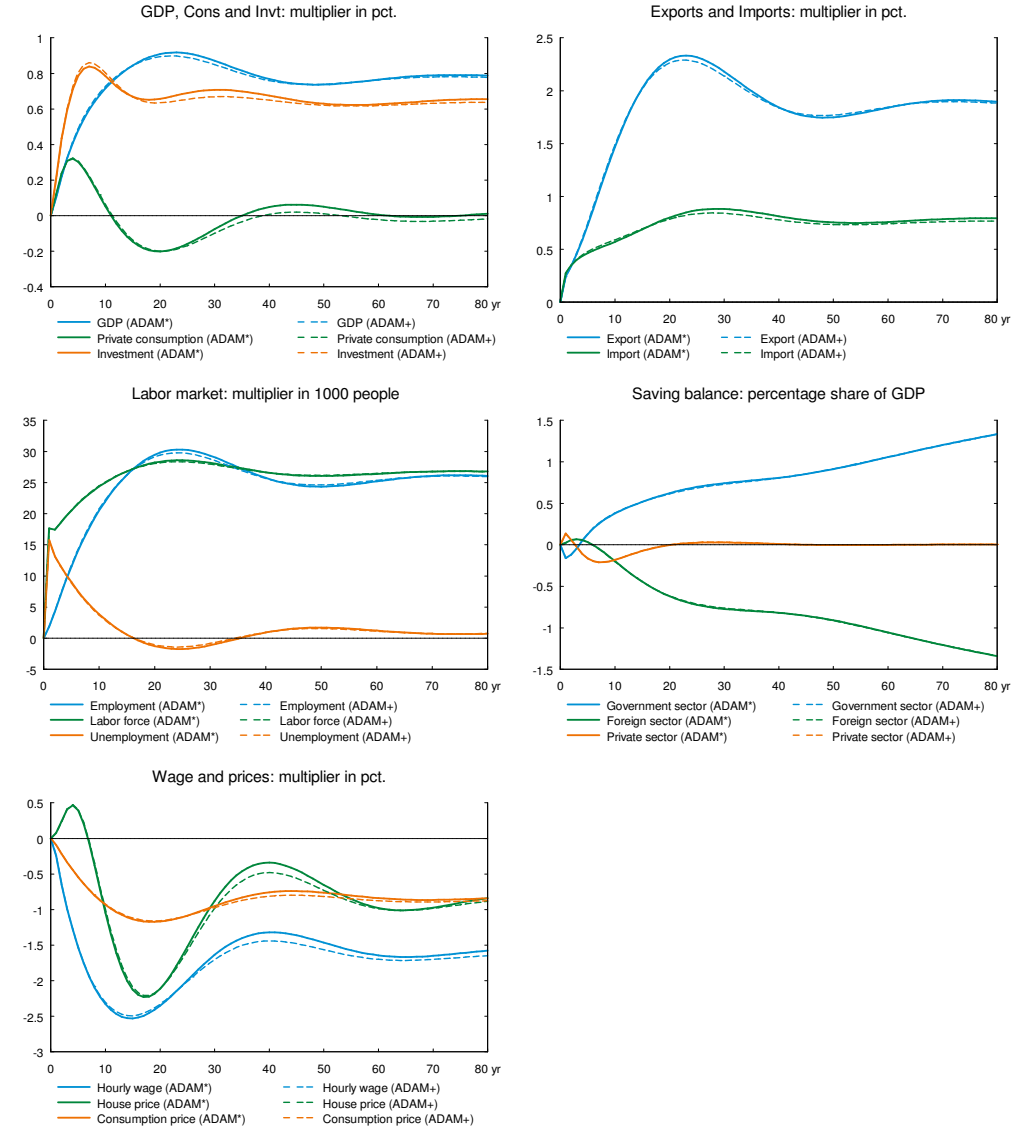
(C) Alternative measure for productivity

As mentioned above, the productivity measure *kqyf* in equation (4*) is defined as the ratio between gross value added and hours worked. Factor inputs in ADAM are expressed in terms of efficiency units that represent technical progress, education and other efficiency enhancing factors. The efficiency indices are determined as part of the factor block estimation and capture trend shifts in productivity. Accordingly, a measure for labor productivity can be constructed using the efficiency indices. We calculate a weighted average efficiency index for labor in the private and public sectors as:

$$Dtl = Dtl_{-1} * [lp_{-1} * Hqp_{-1} * \left(\frac{dtlp}{dtlp_{-1}}\right) + lo_{-1} * Hqo_{-1} * \left(\frac{dtlo}{dtlo_{-1}}\right) / [lp_{-1} * Hqp_{-1} + lo_{-1} * Hqo_{-1}] \quad (5)$$

The average labor efficiency *Dtl* can be used in place of *kqyf* in (4*). Figure 3 compares the two measures for productivity using the labor supply experiment presented in section (A). The multiplier results are very similar. Figure A2 in the appendix repeats the productivity experiment in section (B) using the two productivity measures, again no significant difference is observed, see Appendix for more. For simplicity, it is chosen to use *kqyf* in the current model version, Okt16.

Figure 3. The effect of a permanent increase in labor supply, 1% of employment



Note: In ADAM* *dtl* and in ADAM+ *kqyf* is used to measure productivity.

References

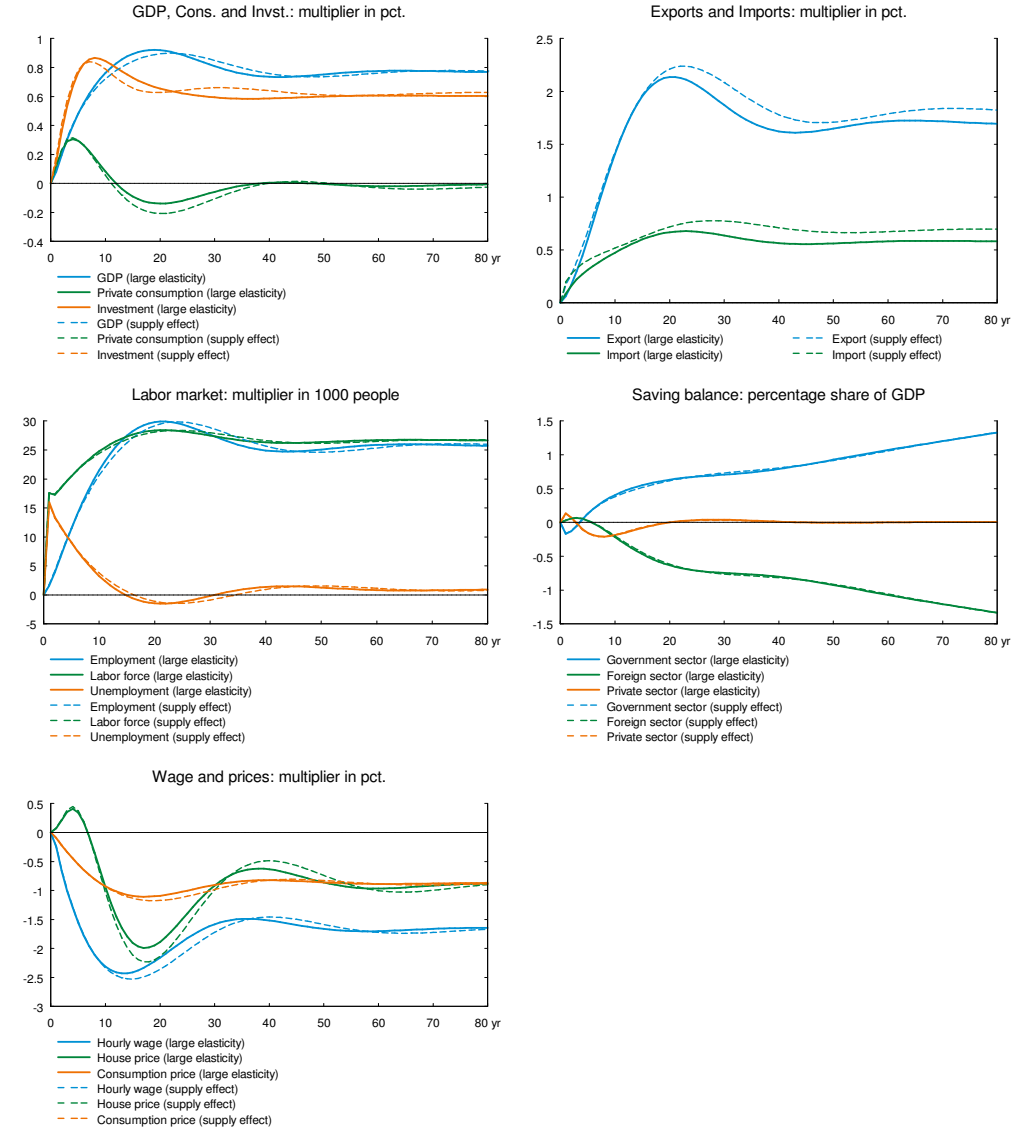
Danmarks Statistik (2013). ADAM: A Model of the Danish Economy, Danmarks Statistik.

Krugman (1989) Differences in Income Elasticities and Trends in Real Exchange Rates, *European Economic Review* 33 1031-1054.

Temere, D.S. and T.M. Kristensen (2016). Supply factors in trade determination. Model-group paper, Statistics Denmark, [DSI080816].

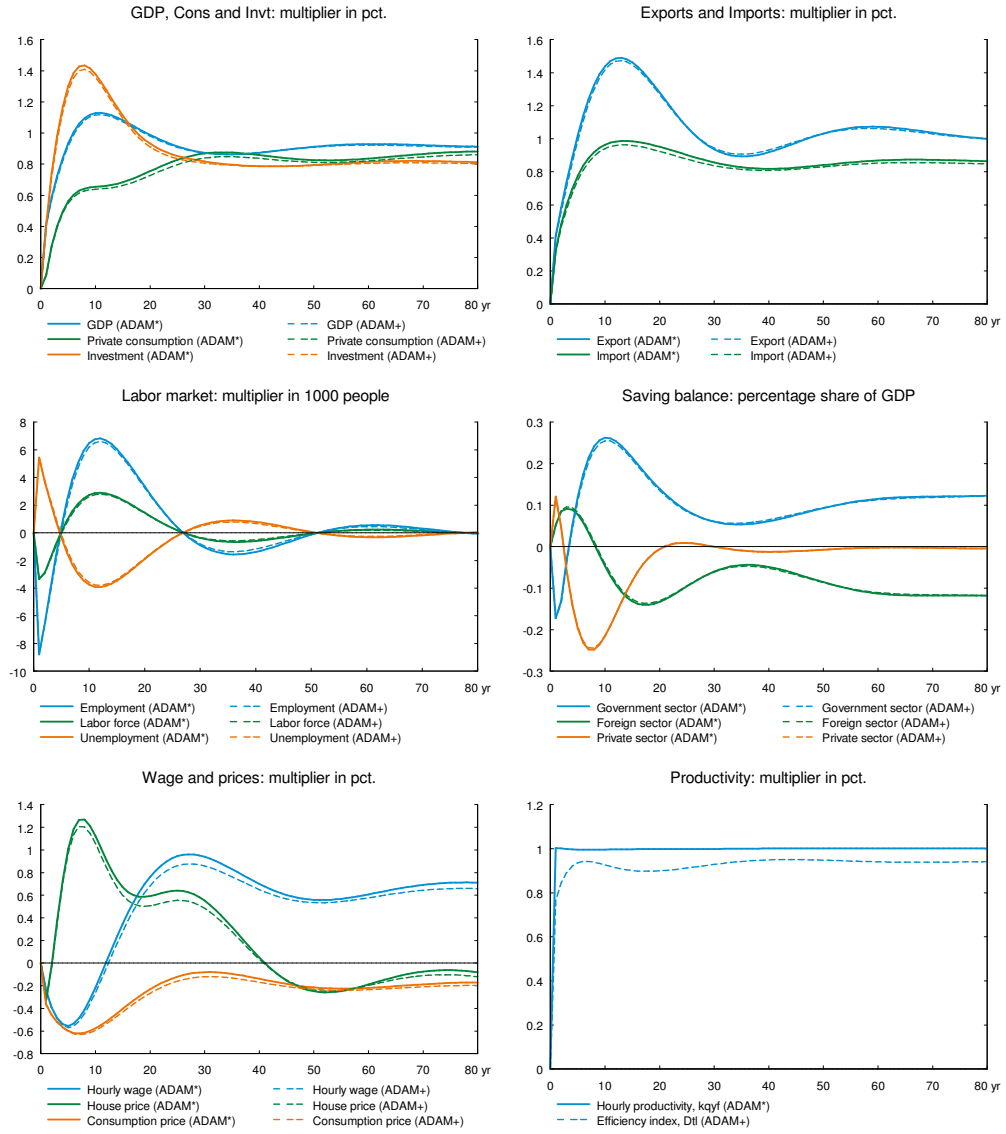
Appendix

Figure A1. The effect of a permanent increase in labor supply, 1% of employment



Large elasticity – the long-term export price elasticities are increased by 40 percent, and no supply effects, i.e. $\theta = 0$.
Supply effect – no change in the export price elasticities and a supply effect of $\theta = 0.7$.

Figure A2. The effect of a permanent 1% increase in labor productivity



Note: In ADAM* *dtl* and in ADAM+ *kqyf* is used to measure productivity.

In the experiment, all labor efficiency indices are increased permanently by 1 percent which corresponds to a 1 percent increase in the average labor efficiency index *Dtl*, see panel (6) in figure 3A. A 1 percent increase in labor efficiency also implies approximately a 1 percent increase in gross value added, since the same amount of labor can now produce higher output. As a result, hourly productivity *Kqyf* = *fyf/Q*Hg* increases also by approximately 1 percent. Hence, the alternative measures for productivity produce similar results.