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Does timing and announcement matter?

Restricting the production of pigs within a dynamic CGE model

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Does timing and announcement matter?
Restricting the production of pigs within a dynamic CGE model[#]

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Abstract

We address the issue of timing and announcement within a dynamic applied general equilibrium model of the Danish economy. Specifically we analyse the introduction of a quota on the production of pigs. Two scenarios are analysed, namely the introduction of a once-off quota without any previous announcement, and secondly an announced gradually phased in production quota. Our findings suggest that the adjustment path is smoother when the policy is announced compared with the one being implemented without warning. This is the result of investors anticipating correctly future adjustments in prices and rental rates when making their investment decisions. Hence, the capital stock starts to adjust from the start of the simulation. When the quota is implemented without warning investors adjusts fully when the quota is implemented. However, the environmental gains are obtained faster in this case due to the method of implementation. In the long run we find that the alternative timing strategies lead to similar results.

[#] The authors thank Søren E. Frandsen for useful comments on an earlier draft of the paper. A previous version was presented to the Fourth Annual Conference on Global Economic Analysis, Purdue University, West Lafayette, Indiana, USA, June 27-29, 2001.

1. Introduction

Over the past thirty years the production of pigs in the EU and Denmark has expanded significantly, leading to environmental concerns related to nitrogen leaching and evaporation of ammonia. Initiatives to limit the pollution have involved two types of intervention: acts that limit the number of pigs per acre; and acts that intend to limit the nitrogen leaching through claims on the production process. The legal number of pigs per acre has been reduced several times since the first implementation in the mid-eighties. Likewise, new claims on the production process have been implemented over the years, e.g., provisions about the storage, delivery, and utilisation of farmyard manure.

The timing of such policy changes is a topic for discussion between farmers, environmental organisations, and policy makers. Farmers argue that pre-announcement and gradual implementation lower the costs of adjustment, leading to reduced social cost. On the other hand, environmental organisations are in favour of acting as soon as possible in order to obtain the environmental gains.

This paper addresses the significance of timing and announcement by analysing the effects of the introduction of a quota on pig production within a dynamic computable general equilibrium (DCGE) model. A quota is one among several conceivable initiatives that may lower the nitrogen leaching and evaporation of ammonia from pig production. Two alternative scenarios are analysed. In the first, the government introduces a quota once off and without warning. In the second scenario, the government announces the introduction of a quota, which is then implemented gradually over a period of four years.

In the literature, there have been several DCGE studies of the long-run effects of a production quota. However, very little attention has been given to the adjustment path and the dependence of the timing of implementation. Malakellis (1997) uses a DCGE model to analyse the effects of implementing a tariff reduction in Australia by surprise, announcement and phasing in. He finds that in the long run effects of the alternative tax reduction strategies are similar, but the adjustment paths are not. Moreover, real GDP is higher in all periods in the case where the tariff cut is implemented without warning (reducing the initial distortions). The slowest and most volatile adjustment path is observed when the tax cut is once off and announced.

The remainder of this paper is organised as follows. Section 2 provides an overview of the theoretical structure of the DCGE model used in this study. In Section 3 we describe the alternative scenarios while the results are explained in Section 4. Section 5 summarises the long-run macroeconomic effects and Section 6 concludes.

2. The model

Over the last five years The Danish Institute of Agricultural and Fisheries Economics has used the Agricultural Applied General Equilibrium (AAGE) model of the Danish economy to analyse economic effects of a number of policy changes. The model is inspired by the Australian ORANI model. The model is a typical static applied general equilibrium model based upon input/output data.[1] Recently, a dynamic version of the model has been developed.[2] The dynamic version is known as Dynamic-AAGE.

In this section we provide a very brief overview of the static part of Dynamic-AAGE. Then we consider the three dynamic relationships within the model: physical capital accumulation, financial asset accumulation, and a lagged adjustment process related to the labour market.

2.1. Overview of the static part of the model

In the current version of Dynamic-AAGE, there are 50 industries that produce 56 commodities. These commodities are sold either to industries as inputs to current production, or to final users including foreigners. The primary factors of production are land, capital and labour. Production takes place according to a nested CES technology, which uses intermediate goods and primary factors as inputs.

There is assumed to be a constant population of identical households. Each household maximises a Stone Geary utility function where only the luxury components of each commodity composite enter into a Cobb-Douglas utility function. This specification gives rise to fixed budget shares for spending on luxuries. The aggregate expenditure level may be determined via the average propensity to consume out of disposable income.

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[1] The model is documented in Frandsen et. al. (1995). Development of the database is described in Jacobsen (1996).

[2] See Adams (2000).

The government sector consumes goods, invests in capital, collects taxes, subsidises production, make transfers to households, accumulates debt, and pay interest.

Export commodities are divided into three groups: traditional exports, non-traditional exports, and special exports. Producers of traditional export goods face downward-sloping foreign demand schedules, whereas foreign demand for non-traditional exports is related to the average price of those goods. Special exports comprise commodities for which special individual modelling is required, e.g., because export of these commodities is insensitive to changes in cost competitiveness in Denmark. It is assumed that the foreign sector supplies the same types of goods as is being produced domestically, and that imports are imperfect substitutes for domestic supplies for all types of domestic agents (the Armington specification).

All agents are assumed to be price takers, with producers operating in competitive markets, which prevents the earning of pure profits. In equilibrium demand equals supply in all markets other than the labour market (where excess supply conditions can hold).

2.2. Physical capital accumulation

Investment

Investment industries produce industry-specific capital using a range of intermediate goods according to a Leontief technology. The investment firms sell the capital to investors who rent it to the goods producing firms for a fee. Investment undertaken in year *t* becomes operational at the start of year *t+1*, so capital available for industry *i* in year *t+1* is given by:

$$K_{t+1}(i) = (1 - \delta(i))K_t(i) + I_t(i)$$

where

$K_t(i)$ is the quantity of capital available in industry i at the start of year t;

$I_t(i)$ is investment in industry i during year t; and

$\delta(i)$ is the rate of depreciation in industry i.

Investment in each industry is assumed to be an increasing function of the expected rate of return on investment in that industry. Investors are assumed to be risk averse, which ensures a finite positive slope of the investment function. Algebraically, investment is determined by an inverse logistic function that relates investment to the expected rate of return on capital:

$$I_t(i) = F_t(i)[EROR_t(i)]$$

where

$EROR_t(i)$ is the expected rate of return on investment in industry i in year t.

Rate of return

The actual rate of return on investment in industry *i* is defined as the net present value of purchasing in year *t* a unit of capital for use in industry *i* divided by the cost of buying or producing a unit of capital in year *t*. It is assumed that investors own the capital for only one period such that the benefits consist of a rental and a depreciated re-sale value and are converted to a present value by discounting with the current rate of inflation. Thus,

$$ROR_t(i) = \frac{-P_t(i) + \dfrac{R_{t+1}(i) + (1-\delta(i))P_{t+1}(i)}{(1+\sigma_t)}}{P_t(i)} = -1 + \frac{R_{t+1}(i) + (1-\delta(i))P_{t+1}(i)}{(1+\sigma_t)P_t(i)}$$

where

$ROR_t(i)$ is the actual rate of return on investment in a unit of capital in industry i in year t;

P_t is the cost of buying a unit of industry i's capital in year t;

R_{t+1} is the rental rate on industry i's capital in year t+1; and

σ_t is the rate of consumer-price inflation in year t.

Expectations

In order to determine the expected rate of return on investment, agents form expectations about future prices and rental rates. The model allows for two types of expectations formations: static and rational expectations.

Under static expectations, it is assumed that investors take account only of current rentals and asset prices when forming current expectations about rates of return. Under rational expectations the expected rate of return ($EROR_t^{RE}(i)$) is set equal to the present value in year *t* of investing $1 in industry *i*, taking account of both the rental earnings and depreciated asset value of this investment in year *t+1* as calculated in the model. In other words, we set:

$$EROR_t^{RE}(i) = ROR_t(i)$$

Since investment in year t depends on rentals and prices in year *t+1*, a solution for year *t* cannot be computed before the solution for year *t+1*. An iterative algorithm solves the problem: In the first iteration we compute recursive solutions for all simulation years under the assumption of static expectations. In the second and subsequent iterations we update the expected rates of return with the actual and expected rates in the first iteration. The procedure continues until convergence is achieved, i.e., until the actual and expected rates of return are identical.

2.3. Financial asset accumulation

The financial asset accumulation equations consist of relationships between net government debt and the government's net borrowing requirement, and between the net holdings of foreign liabilities and the balance on current account in the balance of payments.

Over time the government's annual budget balances determine the government debt. The budget balance is calculated within the model as the difference between government revenue and expenditure. In explaining movements in the budget balance, the model takes into account the net interest payments on the stock of government debt.

Since the economy engages in international trade it may accumulate external debt. The debt is updated over time by the balance on the current account. The balance on the current account is the sum of the balance on the trade account and the income account. The trade accounts is determined as the total value of exports less imports. The balance on the income account is the value of income received from foreigners less the value of income paid to foreigners. Income is the sum of interest, dividend, and transfers received/paid. In explaining movements in the income balance, the model takes into account the net interest and dividend payments on the net external debt.

2.4. Lagged adjustment process

The lagged adjustment process relates to the operation of the labour market in policy deviations. In comparative static analysis, one of the following two assumptions is made about the national real wage rate and national employment:

1. the real wage rate adjusts so that any policy shock has no effect on aggregate employment; or
2. the real wage rate is unaffected by the shock and employment adjusts.

Dynamic AAGE's treatment of the labour market allows for a third, intermediate position, in which real wages can be sticky in the short run but flexible in the long-run and employment can be flexible in the short-run but sticky in the long-run. For year-to-year policy simulations, it is assumed that the deviation in the real wage rate increases through time in proportion to the deviation in aggregate employment from its base-case-forecast level. The coefficient of adjustment is chosen so that the employment effects of a shock are largely eliminated after about ten years. This is consistent with macroeconomic modelling in which the NAIRU is exogenous.

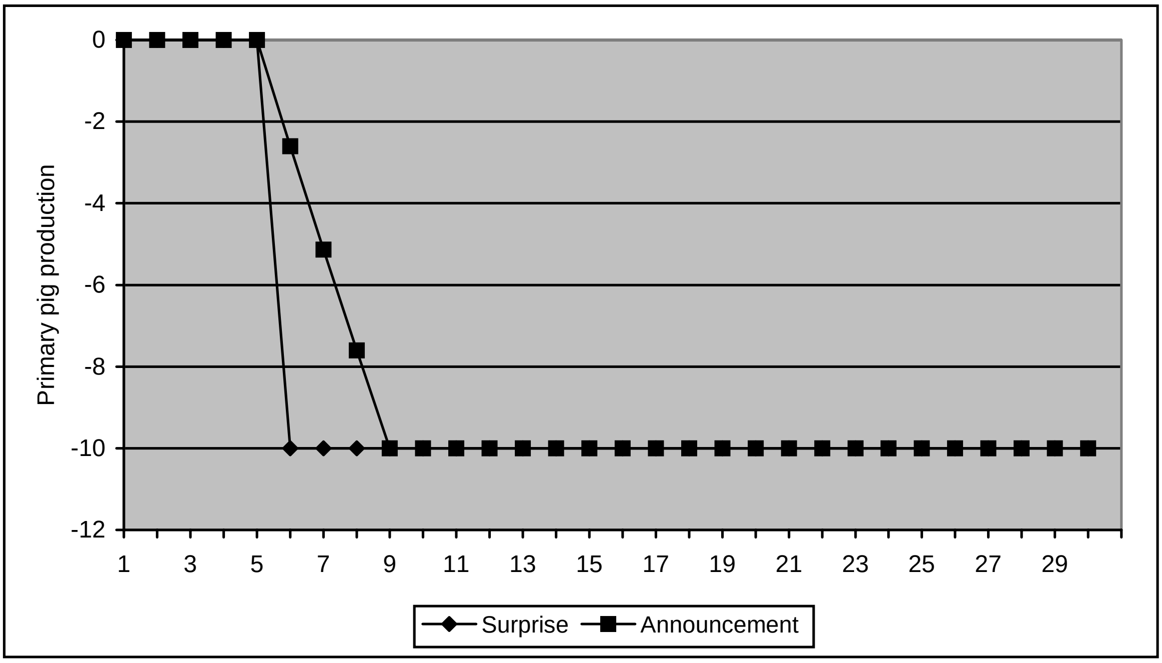
3. Scenarios

The model is solved over a 30-year time horizon and results are reported as percentage deviations from a baseline scenario. The baseline is very plain, allowing us to focus solely on the policy deviations. We model a tradable quota on pig production which allows for policy intervention that limits aggregate pig production. We model the quota by exogenising pig production and introducing an endogenous output tax. The output tax can be thought of as the quota rent per unit of production. The quota revenue is returned to producers as personal income.

We consider two timing strategies. In both scenarios the quota imposes an upper bound on the pig production in year 9 of the simulation and onwards such that the maximum annual production from year 9 and onwards is 10 per cent below the baseline production (see Figure 1). The two timing strategies are:

- **Surprise implementation.** The government implements a quota on the pig production fully in the sixth year of simulation without previous announcement (Figure 1). We model this scenario by assuming static expectations. Under static expectations, investors do not take into account the future when making today's decisions.
- **Announcement.** The government announces the quota at the start of the simulation period and implements it gradually from year 6 to year 9 of the simulation (Figure 1). We model this scenario by imposing a gradually more restrictive quota, and by assuming rational expectations. Under rational exceptions, investors in year *t* take account of developments in year *t+1* when making investment decisions.

Figure 1. The scenarios, deviation from base, per cent



In both scenarios the policy change is initiated in the same year (year 6), which allows us more directly to focus on the issue of announcement. Alternatively we could have analysed the impact of introducing the quota today versus announcing it today and implementing it tomorrow, which from a policy perspective might be of interest. However, by initiating the policy change in the same year we avoid any dependency of the results of the exact dates of policy intervention.

The quota is implemented in year 6 instead of the initial year in order to analyse the pre-shock effects when expectations are rational. Finally, the quota is implemented gradually in the announcement scenario and once off in the surprise scenario in order to highlight the different adjustment paths, i.e. the smoothness of the path in the case of announcement and the volatility of the path in the case of surprise implementation.

The scenarios illustrate both the key implications of the two types of expectations formations and the effects of announcement versus surprise intervention. When the pig production quota is implemented without previous announcement, adjustment must take place in year 6 and onwards. Therefore, in year 6 the demand for capital suddenly decreases sharply in the pig industries. As the capital supply is fixed the rental rate on capital bears the full adjustment in the initial year.

When the pig quota is announced and agents form rational expectations, adjustments begin in the first year of simulation. The transitional path is, therefore, likely to be smoother in this case since agents anticipate correctly future adjustments in prices and rentals when making today's investment decisions. In the long run the two scenarios deliver similar economic effects.

4. Results

First, we discuss the results in the case of surprise implementation. Then we discuss the results in the case of announcement by relating our main findings in this scenario to the first scenario.

4.1 Surprise implementation

The main effects of the surprise implementation of the pig quota on industry and macroeconomic variables are shown in a series of Charts. These show, for years 1 to 30, deviations of a range of variables in the policy simulation from their values in the base case. For example, Chart 1.1 shows that the quota increases the basic price of pigs in year 6 by around 9 per cent relative to its basecase value in that year.[3]

Our explanation focuses on the charts. The italicised headings outline the main structure of the explanation.

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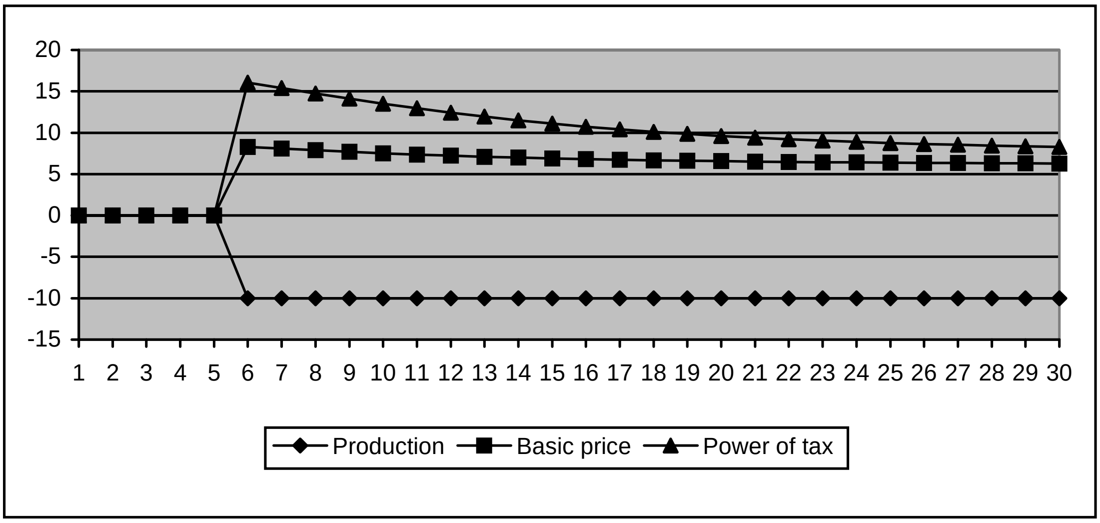
[3] The basic price equals the producer price (i.e., the price received by the producer) plus the specific output tax

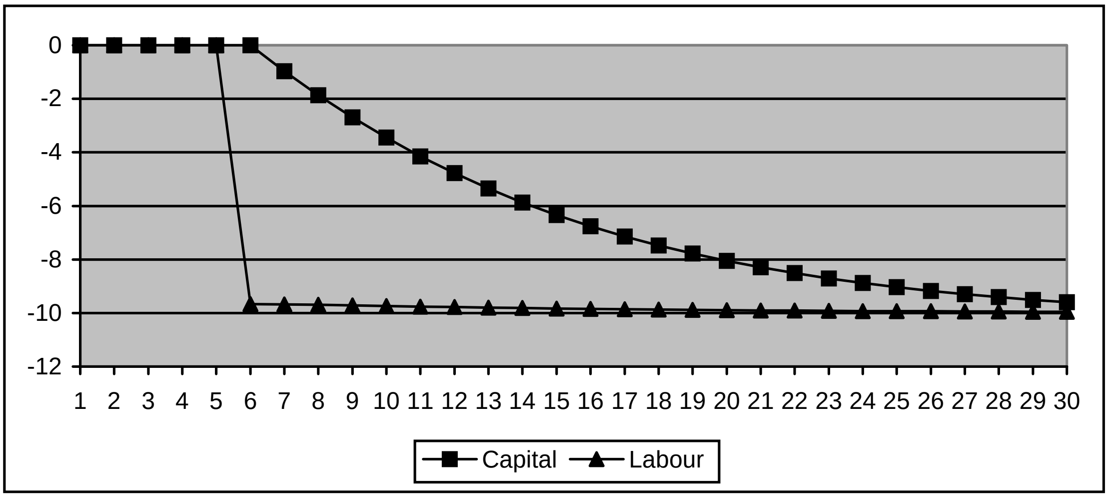
In the short run, the quota requires an output tax of 15 per cent, lowers primary pig production by 10 per cent compared to the base case, and increases the basic price of pigs by around 9 per cent relative to base[4]

Chart 1.1. Pig production, price and tax, percentage deviation from base



Over time, the power of the tax required to bring about the production slowly falls to a level approximately half that initially required. This reflects the adjustment of capital

Chart 1.2. Primary inputs to pig production, percentage deviation from base



[4] The power of the output tax is equal to one plus the specific output tax. Initially, the specific tax is zero and the basic price of pigs is one. Thus a 15 per cent increase in the power leads to a change in the value of the output tax from its basecase value of zero to 15 per cent of the basic value of pig production.

Since capital is initially fixed the imposition of the quota leads to a significant fall in the rental rate on capital, and hence to the rate of investment in pig production. Capital gradually follows with a lag. The reduction in capital is accompanied by reduced employment. Over time, capital adjusts to return the rental on capital back to its base case value, leaving capital and labour permanently below base by around 10 per cent. The contraction in primary inputs means that, over time, the output tax required to achieve the contraction in output steadily falls.

In the short run, the quota reduces employment. With capital fixed, this leads to a fall in real GDP at market prices.

The main reason for the initial decline in employment is that the output tax on pig production raises the real cost of employing labour, i.e., raises the real wage rate from the employers' point of view.[5] The tax puts a wedge between the price of expenditure (the consumer price index, for example) and the price received by producers (the deflator for GDP at factor cost). With the after-tax real wage rate from the employee's point of view assumed to be sticky in the short run, the nominal wage diverges only slowly from the consumer priced index.[6] Hence, initially the nominal wage rises relative to the factor cost GDP deflator.

Chart 1.3. Real GDP and primary inputs, percentage deviation from base

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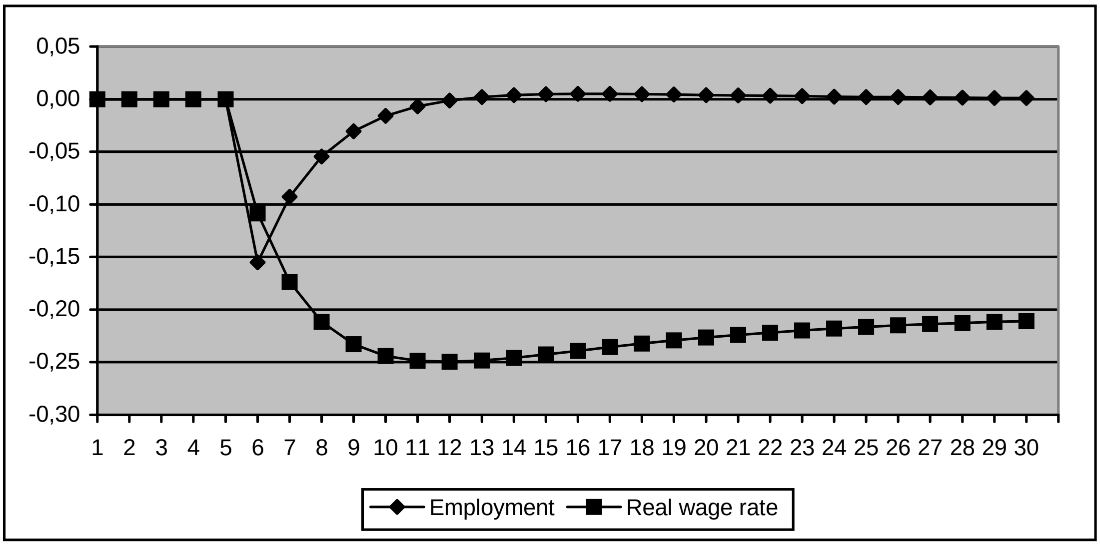
[5] The employer real wage rate is the nominal wage rate deflated by the price of output. At the macro level, the price of output is equivalent to the price of GDP at factor cost.

[6] The employee real wage rate is the nominal wage rate deflated by the CPI. In the short-run, the employee real wage is sticky. Hence the nominal wage rate tends to move with the CPI.

Over time, employment moves slowly back towards its basecase level, as the real wage rate falls.

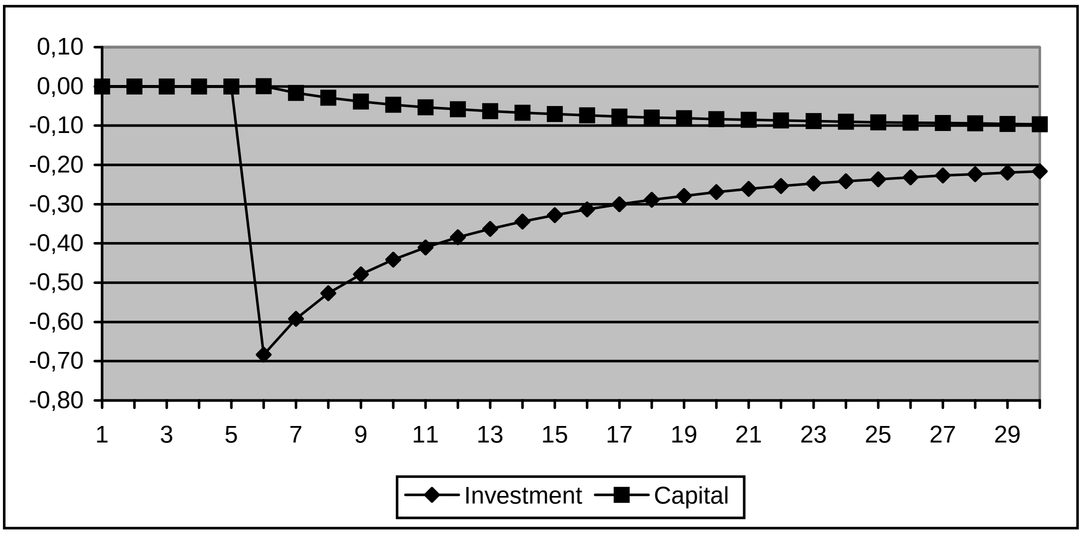
According to the labour-market specification in Dynamic-AAGE, if employment is below its basecase level, employees allow a decrease in their real wage rate. This strengthens producers' incentives to substitute labour for capital, leading to an increase in the ratio of labour to capital. Consequently, in our simulation employment recovers over time.

Chart 1.4. Employment and real wage rate, percentage deviation from base



As employment recovers, capital progressively falls away from basecase levels.

Chart 1.5. Real investment and capital, percentage deviation from base



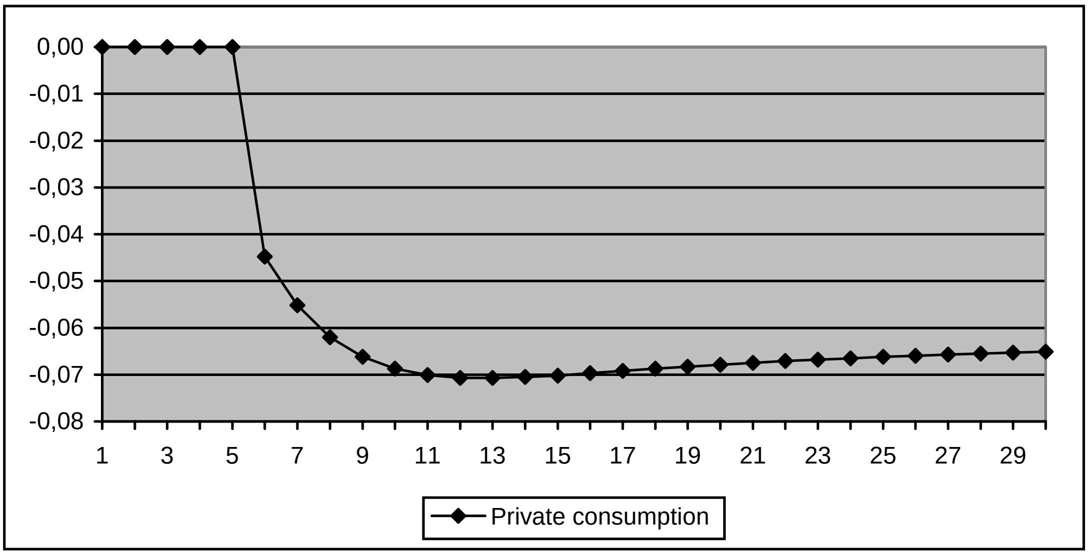
In year 30, the employment deviation has been eliminated, but the real wage rate is down 0.2 per cent, the capital stock has fallen 0.1 per cent, and real GDP has been reduced by around 0.06 per cent.

Investment remains below base to accommodate the fall in capital.[7]

Investment deviates to accommodate changes in capital. Thus, with capital progressively falling below base, investment must remain below its basecase levels. In year 30, investment is about 0.2 per cent below its basecase level.

Private consumption declines slightly.

Chart 1.6. Real private consumption, percentage deviation from base



In our modelling, private consumption moves in line with Household Disposable Income (HDI). HDI takes account of capital and labour income accruing to domestic residents, government transfers to households, income tax paid by households, *and* the revenue from the pig quota. If none of the quota revenue were returned to consumers, then in the first year of the shock HDI would fall by around 0.3 per cent. In that year the quota revenue accruing to domestic residents is equivalent to 0.2 per cent of con-

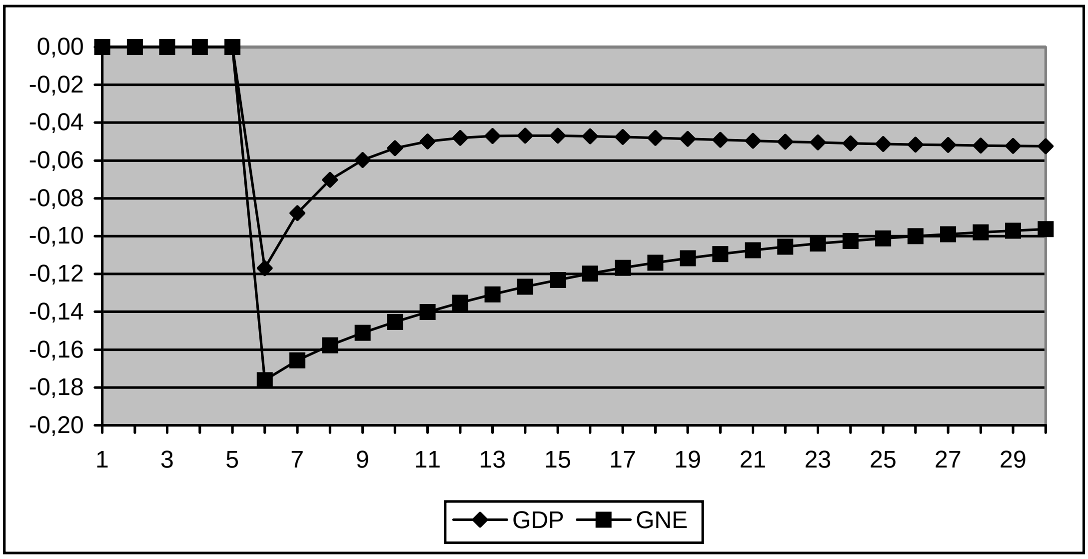
[7] The distance below base of the investment line in Chart 5 is related to the slope of the capital line in Chart 5. If the capital line is getting steeper (less steep) the investment line will be moving further away from (closer towards) base.

sumption. Receipt of this income helps to offset the fall in income from capital and labour, leaving real private consumption around 0.1 per cent below base.

Over time, private consumption falls progressively further below base, as the falls in income from conventional sources outweigh increases in income from the quota revenue.

Real gross national expenditure (GNE)[8] *declines by more than real GDP, leading to an improvement in the balance between export and import.*

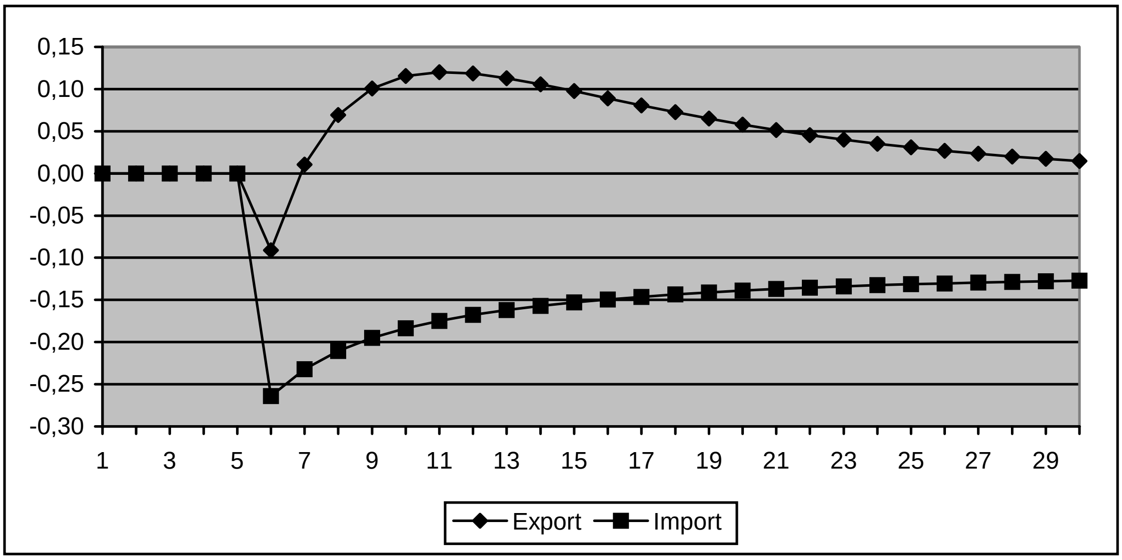
Chart 1.7. Real GDP and GNE, percentage deviation from base



Public consumption is assumed to move with private consumption. Real private consumption declines in line with real HDI. The decline in HDI is similar to the decline in real GDP, partly reflecting the return of quota revenue to domestic residents. However, the decline in real investment is larger than the decline in real GDP such that overall the percentage declined in real GNE is greater than the percentage decline in real GDP, leading to an improvement in the balance between export and import volumes. To achieve this improvement, the real exchange rate depreciates (see Table 1). The depreciation is made stronger by the deterious effects of the quota on exports of pig meat.

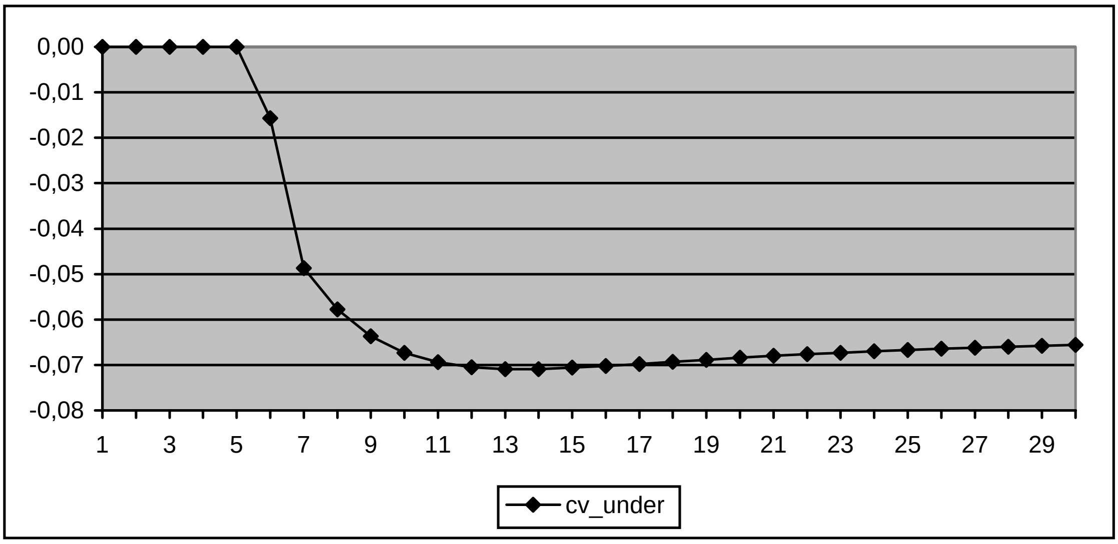
[8] The percentage change in real GNE is the weighted average of percentage changes in real private consumption, real public consumption and real investment.

Chart 1.8. Trade volumes, percentage deviation from base



The production quota damages welfare.

Chart 1.9. Welfare, per cent of aggregate consumption in the base case forecast

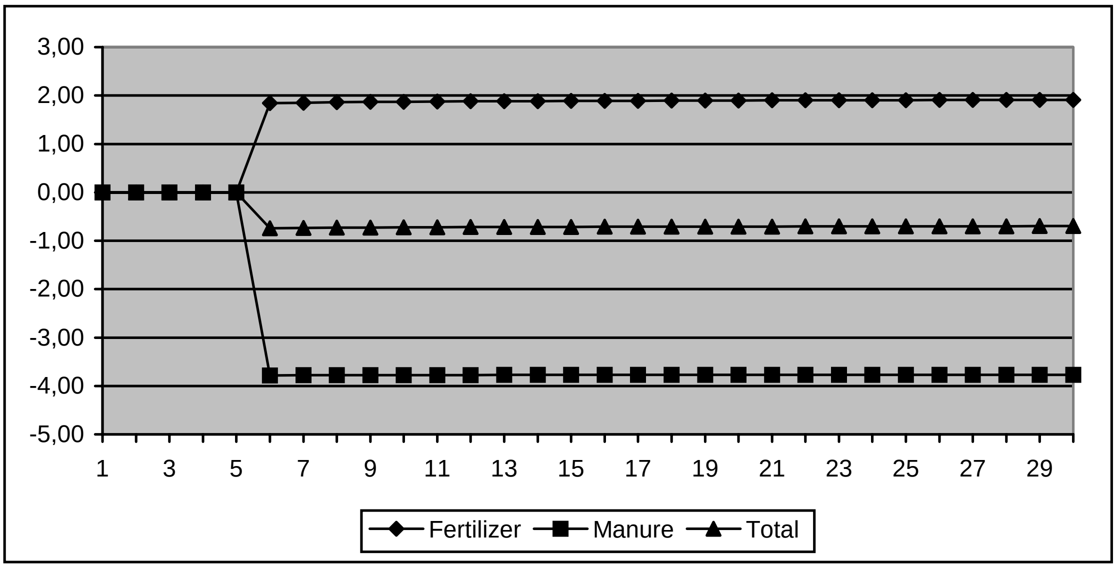


We employ two welfare measures, which are called *EV_OVER* and *CV_UNDER*. Both are simple measures that have the advantage of not relying on a specific household utility function. Equivalent variation can be thought of as the amount of additional income that consumers would require before the policy change to make them as well off as after the policy change. *EV_OVER* is the amount of money that would need to be given to consumers in the forecast situation (before the policy change) to enable them to just buy the policy consumption bundle. Thus, *EV_OVER* is an over-estimate of the equivalent variation; it over-estimates the amount of money that must be given to consumers to enable them to buy a consumption bundle, which generates the policy, level of utility.

Compensating variation can be thought of as measuring the income that must compensate consumers for the policy change after it occurs in order to return consumers to their original level of utility. *CV_UNDER* is the amount of money that could be taken away from consumers in the policy situation and leave them just able to buy the forecast consumption bundle. Thus, *CV_UNDER* is an under-estimate of compensating variation; it under-estimates the amount of money that could be taken away from consumers in the policy situation and leave them able to buy a consumption bundle which generates the forecast level of utility. In Chart 9 it can be seen that a negative amount of money could be taken away from consumers in the policy simulation and leave them just able to buy the forecast bundle, that is, they would have to be compensated with an amount of money in the policy simulation in order to enable them to buy the forecast bundle.

While the quota damages economic welfare, there are environmental gains due to the lower pig production, which lower the nitrogen leaching, the evaporation of ammonia and the use of manure in agriculture.

Chart 1.10. Use of nitrogen, percentage deviation from base



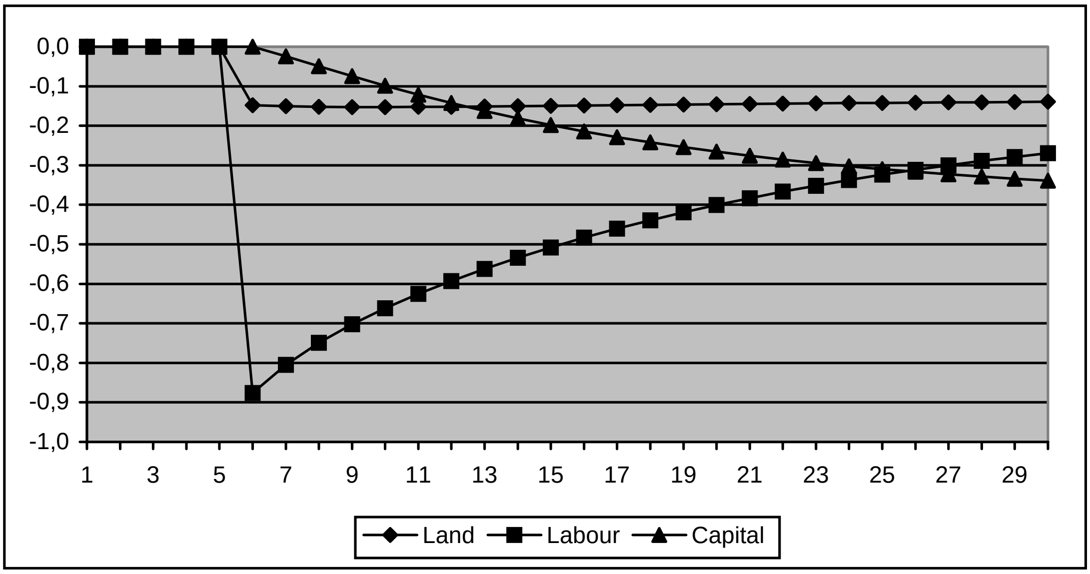
We only report one measure of the environmental gains, namely the effects of the pig quota on the use of nitrogen in the economy. We measure the use of nitrogen in the form of manure and fertilizer, respectively. We also report a measure of the total use of nitrogen as a weighted sum of the use of nitrogen in the two forms. It is seen that the production and use of nitrogen in manure decreases by almost 4 per cent due to the lower pig production. The production of milk and cattle is unchanged by the quota since the milk industry is itself a quota industry.

The lower production of nitrogen in manure is partly substituted by larger use of nitrogen in fertilizer.

The use of nitrogen in fertilizer increases by almost 2 per cent. Overall, though, the quota benefits the environment since the total use of nitrogen in the economy decrease by 0.7 per cent.

The lower production of primary pigs implies lower demand for inputs such as grains.

Chart 1.11. Primary inputs to grain industry, percentage deviation from base

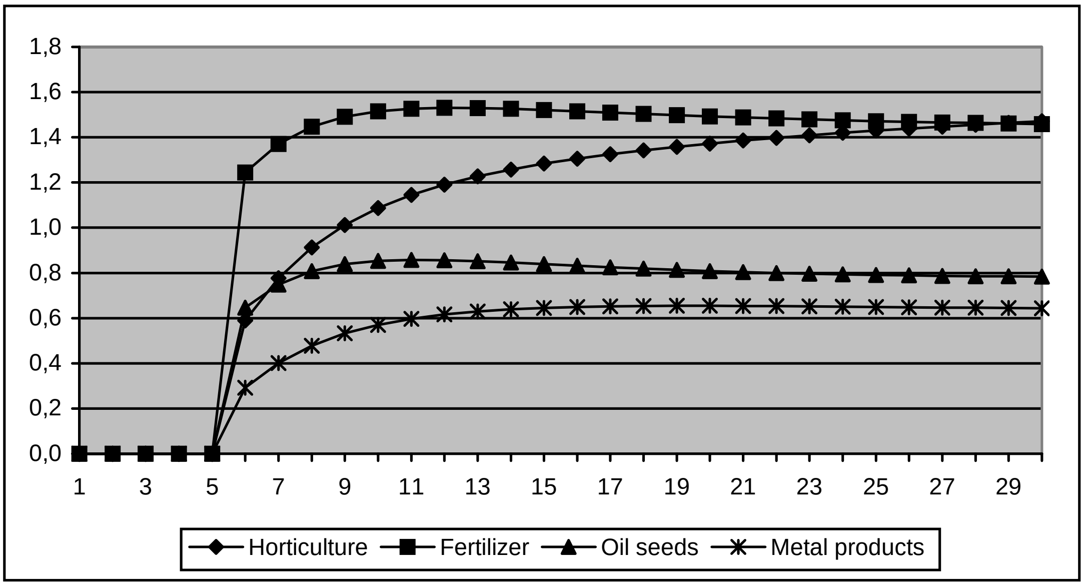


Primarily four industries loose due to the quota: the primary pig industry, the pig-meat industry, and the agricultural services and grain industries being main input suppliers to the pig industry. The adjustments in the pig manufacturing industry replicate the adjustments in the primary pig industry. In the agricultural services and grain industries the lower demand for it's product results in lower demand for primary inputs.

Initially the capital stock is fixed, so the rental rate on capital bears all the adjustment. However, the lagged adjustment process in the labour market prevents the wage rate from adjusting fully in the early years after the policy change, and the hectare premium acts as a buffer to changes in the price of land. Therefore, the relative prices of capital to labour and capital to land fall even though both the real wage and the price of land decrease. As a consequence the agricultural services and grain industries become more capital intensive in the short run. In the longer run the wage rate adjusts to clear the labour market while the rental rate of capital returns to it's basecase level such that the capital-to-labour ratio decreases while the capital-to-land ratio in the grain industry stays below base.[9]

Most other industries gain through the policy intervention.

Chart 1.12. Output of top-four winning industries, percentage deviation from base



The lower price on labour, land and on intermediates enable other industries to increase production at lower unit costs.

[9] In a later version of the model the specification of the grain industry has changed. The changes imply that the grain production is less sensitive to changes in the pig production since the prices of grain are to a large extent determined by the world market prices. Hence, when the domestic demand for grain decreases, the export of grain increases leaving the domestic price and production of grain unchanged.

Only a few industries use agricultural land as an input to production, but those that do obtain larger gain compared to those that do not use land due to the fall in the price of land. Two such industries are the horticulture and oil seeds industries, which increase production by approximately 1.5 and 0.8 per cent, respectively.

The fertilizer industry gain through lower unit costs of production and through increasing demand due to the decreasing production of manure in the pig industry. Hence, the production of fertilizer increases by almost 1.5 per cent relative to base.

The output of metal products increases due to lower unit costs in that industry and due to increasing demand for metal products from other domestic industries such as the construction industry and the machinery equipment industry.

The top-four winning industries are very trade-exposed with nearly half of their total sales exported, and with imports comprising over half of all sales in the local market. Therefore, the industries gain through the real devaluation too.

4.2 Announcement

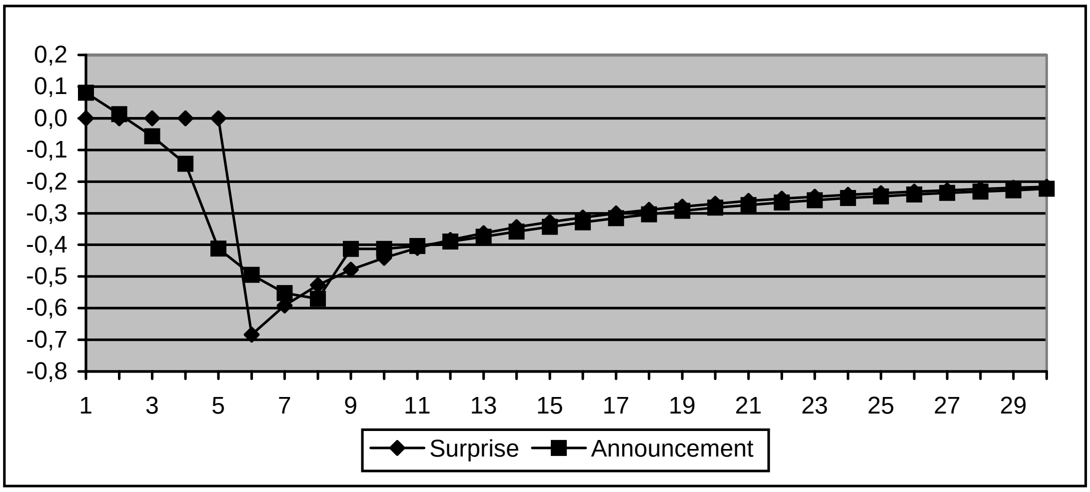
In this scenario we switch both expectations formations and method of implementation by assuming that agents form rational expectations, and that the quota is implemented gradually over four years. We interpret the scenario as if a quota is announced at the start of the simulation such that four years before the quota is put in place producers start to change production decisions in anticipation of the 10 per cent reduction in production to be imposed.

We analyse how this scenario differs from the previous scenario with respect to adjustment paths and long run effects.

When the quota is announced there are pre-shock effects on investment: investors' be haviour adjusts to the future change in policy from the start of the simulation.

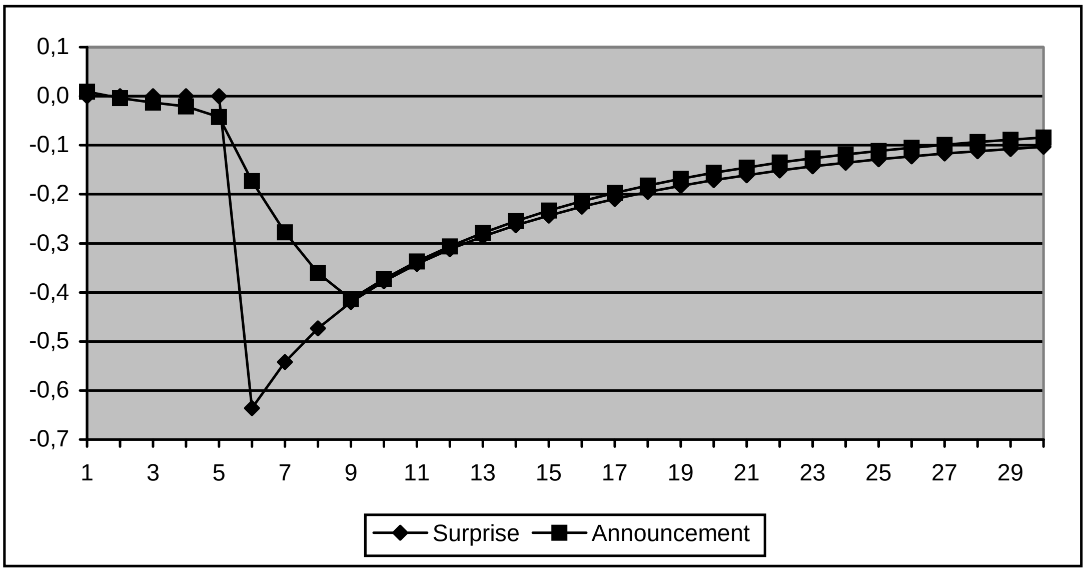
From the outset, investors take into account that the quota will drastically reduce profitability in the pig and pig-related industries. Thus investment starts to decline, even before the quota is put in place.

Chart 2.1. Aggregate real investment, percentage deviation from base



Compared to the case of implementation without warning, the rental rate on capital does not decrease as sharply when the quota is announced.

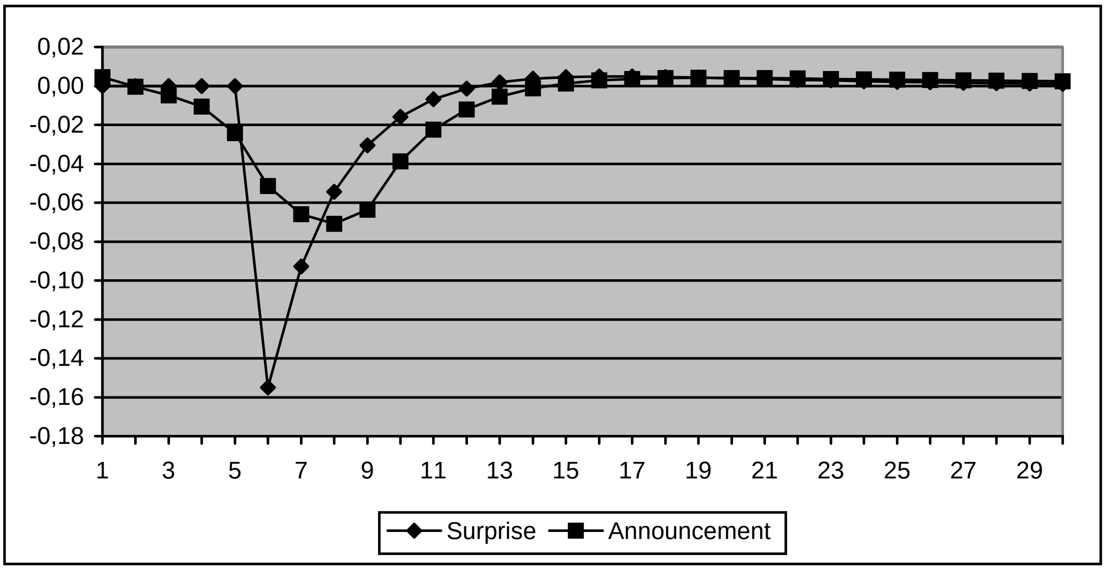
Chart 2.2. Rental rates on capital, percentage deviation from base



The pre-shock effects ensure a smoother path of adjustment of investment than in the previous scenario (Chart 2.1). Therefore, adjustment does not require the rental rates on capital to decrease as sharply as in the surprise implementation scenario, and we observe a more smooth adjustment path of the weighted capital rental when the quota is announced.

The adjustment path of aggregate employment is smoother when the quota is announced than when it is implemented without warning, but in the long run aggregate employment returns to the basecase level in both scenarios.

Chart 2.3. Aggregate employment, percentage deviation from base

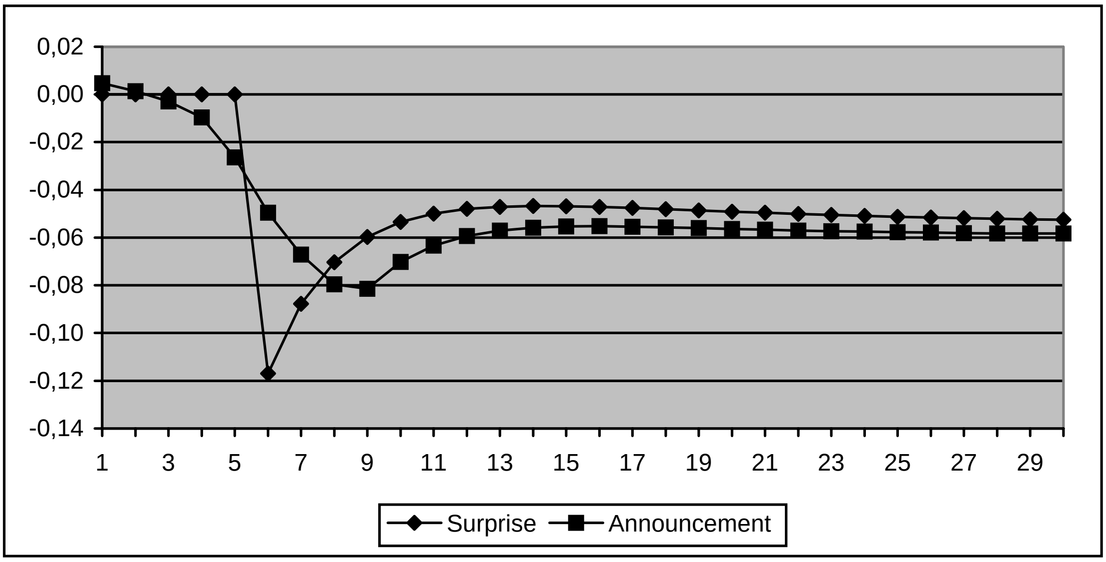


As producers start to adjust production, so do they adjust their input requirments. Hence, the demand for labour decreases from the start of the simulation. But since the wage rate adjusts only slowly there are some temporary effects of the policy change on aggregate employment. In the longer run, the real wage adjusts so the two scenarios delivers identical aggregate employment levels. Note that the smoother adjustment in the announcement scenario is achieved at the cost of lower employment in a couple of years before the quota is actually implemented.

In the announcement scenario, Real GDP falls below base before the quota is implemented. After the quota is implemented real GDP is higher in the announcement scenario than in the surprise scenario.

Due to the pre-shock effects on aggregate employment and investment we observe a drop in GDP in the years before the quota is implemented in the announcement scenario. In the surprise scenario real GDP decreases significantly more than in the announcement scenario in the years immediately following the quota implementation. This is the result of the huge adjustment in aggregate employment that is required because the capital stock is initially fixed when the quota is implemented without warning.

Chart 2.4. Real GDP, percentage deviation from base

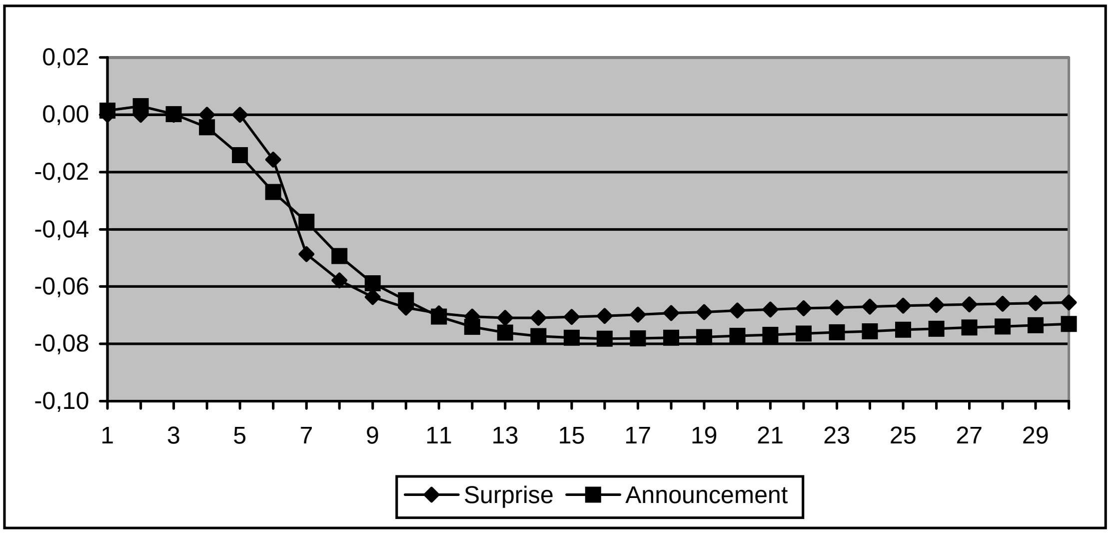


In the long run real GDP converges to the same levels in both scenarios. By comparing charts 2.3 and 2.4 it is seen that real GDP converges slower than does aggregate employment in the two scenarios. This is because the development of real GDP depends on accumulated capital, which is more sluggish than employment. Chart 2.2 reveals that in this model the adjustment of capital is indeed sluggish: the rental rate on capital is still 0.1 per cent below the baseline level 24 years after the quota has been implemented. However, if we were to increase the simulation period by 20 years we would observe perfect convergence between the capital stocks in the two scenarios.

There exists a trade-off between smoothness and pre-shock effects on welfare: in the years of implementation welfare is damaged to a larger extent when the quota is implemented without warning than when it is pre-announced. However, there are negative pre-shock effects on welfare when the quota is announced.

The pre-shock effects imply a more smooth adjustment path in the announcement scenario. The smoothness ensures a smaller drop in aggregate employment in the years when the quota is implemented compared to the surprise implementation scenario. However, the smoothness is achieved at the cost of lower GDP and aggregate employment in the years before the quota is implemented compared to the surprise implementation scenario. This trade-off is repeated in chart 2.5, which illustrates the development of welfare in the two scenarios.

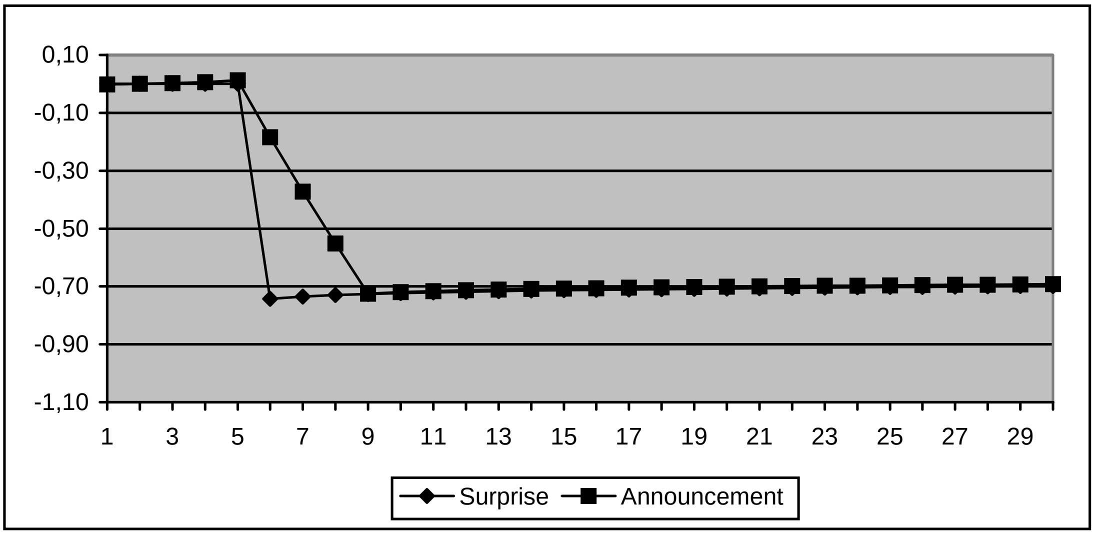
Chart 2.5. Welfare, per cent of aggregate consumption in the base case forecast



The trade-off between smoothness and pre-shock effects does not exist when it comes to environmental gains: the quicker the quota is implemented, the sooner are the environmental gains obtained but in the long run the method of implementation does not matter for the environment.

In the long run the use of nitrogen in the economy decreases by 0.7 per cent in both scenarios.

Chart 2.6. The use of nitrogen, percentage deviation from base



5. Long-run macroeconomic effects

To summarise the long-run implications of introducing a quota on the production of pigs, Table 1 shows the long-run macroeconomic effects. While the adjustment path, as reported above, differs somewhat between the two scenarios analysed, the simulated long run equilibrium is almost identical in the two scenarios.

Table 1. Long-run macroeconomic effects, deviation from base, percent

Real GDP	-0.05
Real private consumption	-0.07
Real public consumption	-0.07
Real investment	-0.24
Real export	0.03
Real import	-0.13
Real capital stock	-0.09
Real devaluation	0.20
Terms of trade	0.04
GDP deflator	-0.04
Price of capital	-0.04
Rental rate on capital	-0.13
Price of labour	-0.22
Price of land	-3.15

Note: The results shown are from the surprise implementation scenario. The results generated in the announcement scenario are similar.

Reducing the production of pigs by 10 per cent compared with the base case leads to a decline in the export of pig meat by 12 per cent. However, as the export of other commodities increase somewhat due to a real devaluation, the total real export increases by 0.03 per cent. The environmental inspired policy change leads to a 0.24 per cent lower investments and a 0.09 per cent lower level of the real capital stock in the long run. Real GDP and real private consumption decline by 0.05 and 0.07 per cent, respectively, and the total real import falls by 0.13 per cent[10]. The overall lower level of activity in the land using sectors leads to a 3 per cent fall in the price of land.

[10] The decrease in real GDP may be explained as follows. The real return to capital (i.e. the nominal rental on capital relative to the price of GDP at factor cost) increases by the same as the value of the output tax to GDP which is 0.1 per cent in the long run. Increase in real return to capital reduces the real return to fixed factors (labour and land) by 0.1 per cent times the ratio of capital to fixed factors (around 0.5). This gives a decrease in the real return to fixed factors of approximately 0.05 per cent. Therefore, capital becomes 0.15 per cent more expensive than the fixed factors. Since the average capital/labour substitution elasticity of the economy is 0.6 this implies a 0.1 per cent fall in the ratio of capital to fixed factors. Given that capital is 35 per cent of GDP and labour is fixed in the long run, a 0.1 per cent fall in capital implies a 0.04 per cent fall in real GDP. We observe a slightly larger fall in GDP because the pig industries are very capital intensive, so in the long run the pig industries can get rid of capital and labour in roughly equal percentage proportions by allowing the rest of the economy (which is labour intensive) to absorb the labour shed by the pig producers with relatively little change in relative factor costs.

6. Conclusions

In this paper, we address the issue of timing and announcement within a dynamic applied general equilibrium model of the Danish economy. In the model, investment is assumed to be an increasing function of the expected rate of return. The rate of return depends on the price of capital and the rental rate on capital in the next period. The model allows for two alternative specifications of expected prices and rentals: static expectations and rational expectations.

We analyse two scenarios that illustrate the key implications of the two types of expectations formations and the effects of timing. In the first scenario the government implements a quota on the production of pigs fully in one year without previous announcement. We model the surprise issue by assuming static expectations. In the second scenario the government announces the quota at the start of the simulation period and implements it gradually over four years. In this scenario we employ rational expectations such that agents correctly anticipate future prices and rentals.

Our findings suggest that timing and announcement matter. The adjustment path is smoother when the policy change is announced than when it is implemented without warning. The environmental gains are, however, obtained faster when the quota is implemented once-off than when it is phased in. In the long run the two scenarios deliver similar economic and environmental effects. The convergence between the two scenarios may, however, take a long time, that is more than 20 years.

We have modelled the announcement scenario by implementing the quota gradually over a period of four years; so one could wonder whether the smoothness result is solely due to the smoothness of implementation. Do announcement and rational expectations matter at all? Our work suggests that the answer is yes. Simulations with static expectations reveal a more volatile adjustment path even when the quota is implemented gradually. This is due to the fact that any policy change is a surprise to agents so they have to adjust behaviour each year after the policy has changed.

Since the alternative timing strategies imply the same long-term development of the economy, the economic costs are similar in the long run. However, in the shorter run smoothness is achieved at the costs of more persistent drops in GDP, employment, welfare, etc. So whether announcement or surprise implementation is to be preferred depends on agents' attitudes towards risk and how they discount the future. The more risk averse are agents and the less they discount future consumption, the more likely it is that they prefer announcement. In this model, households do not make intertemporal consumption decisions, so it is not suited for analysing these issues. It may be a topic for future research.

Malakellis (1997) compares three tariff cut scenarios. Among these is a scenario where the tariff cut is implemented in the first year of simulation (surprise implementation) and a scenario where the cut is announced at the start of simulation and impelemnted in year 12 (announcement). He finds that it is preferable to implement the cut in the first year without warning. The reason for this result is that in the announcement scenario the costs of capital decrease and the rental rates of capital increase in year 12. Therefore, investors delay investment and allow the capital stock to decrease gradually such that the efficiency gains are delayed until after year 12. When the cut is implemented in the first year of simulation, the efficiency gains are realised immediately. In this analysis we deliberately try to avoid the dependency of the time of implementation of the policy change and focus on the announcement issue. The analysis suggests that the smoother adjustment in the case of pre-announcement may be preferable under some circumstances. Therefore, it is not possible from an economic perspective to list the two scenarios a priori. However, in line with Malakellis' results we find that the environmental gains are obtained faster when the policy change is implemented once off than when it is implemented gradually.

Since dynamic-AAGE has just recently been developed there are still room for further improvements of the model, the database, and the base case forecasts. The agenda includes refinement of the households' expenditure system, the treatment of external debt and the specifications of export volumes. With some of these improvements in place, the model will be better able to address issues like that addressed in this paper, and will be able to handle additional ones such as alternative strategies for reducing pig production and the adjustment problems of converting conventional farming into organic farming.

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