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

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Abstract

In this paper 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. In the long run, however, we find that the alternative timing strategies lead to similar results.

1. Introduction

During the last decades the production of pigs in the EU and Denmark has expanded significantly and led to environmental concerns of the nitrogen leaching and evaporation of ammonia. Initiatives to limit the pollution have involved two types of intervention: legal acts that limit the number of pigs per acre and legal 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. The farmers argue that pre-announcement and gradual implementation lower the costs of adjustment, which reduce fluctuations and economic costs to society. On the other hand, environmental organisations are in favour of acting as soon as possible in order to obtain the environmental gains.

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This paper addresses the significance of timing and announcement. For illustrative purposes we analyse the sector and economy-wide effects of the introduction of a quota on the pig production within a dynamic general equilibrium 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, and they differ according to the timing of implementation. In the first scenario the government introduces a quota once off and without warning, while 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 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) analyses 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 dynamic applied general equilibrium model of the Danish economy. In section 3 we describe the alternative scenarios while the results are explained in section 4. Section 5 concludes.

2. The model

The last five years The Danish Institute of Agricultural and Fisheries Economics have used an 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 analysis presented in this paper is our first experience with this recently developed dynamic version of the general equilibrium model of the Danish economy, and the results are therefore to be considered as preliminary.

In this section we provide a very brief overview of the static part of the model. 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. For the results, the physical capital accumulation is the key dynamic feature. Therefore, we explain more carefully the mechanisms behind physical capital accumulation while we only briefly mention the asset accumulations and the lagged adjustment process.

2.1. Overview of the static part of the model

The model consists of 39 goods producing industries that produce 45 commodities, which can be used for either consumption or production. The primary factors of production are land, capital and labour. Hence, the production takes place according to a nested CES technology, which uses intermediate goods and primary factors as inputs. Four additional types of agents demand the output

[1] The model is documented in Frandsen et. al. (1995) while the development of the database is described in Jacobsen (1996).
[2] Adams (2000) explains in depth the dynamic structure of the model.

from the goods producing industries: households, a government sector, investment industries, and a foreign sector.

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 enters 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.

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

Commodities are divided into two groups: traditional exports and non-traditional 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. 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 for each type of domestically produced commodity and primary factor of production.

2.2 Physical capital accumulation

Investment

Investment industries produce industry-specific capital using the 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 slope of the investment function. Algebraically, investment is determined by an inverse logistic function that relates investment to the expected equilibrium rate of return on capital. The expected equilibrium rate of return can be interpreted as the expected rate of return required by investors to sustain indefinitely the current rate of capital growth in industry i. An expected disequilibrium rate of return arises because the expected rate of return and capital growth rate in the initial year do not necessarily satisfy the inverse logistic function.

Investors are willing to supply increased funds to industry i in response to increases in the expected equilibrium rate of return in that industry. However, investors are cautious: they are willing to allow the rate of capital growth to move above the historically normal rate only if they expect to be compensated by a rate of return above the historically normal level:[3]

$$ln\left(\frac{\gamma_t(i)-\gamma^{MIN}}{\gamma^{MAX}-\gamma_t(i)}\right)=c(i)[EROR_t^{EQ}(i)-ROR^{NORM}(i)-F_t(i)]+ln\left(\frac{\gamma^{NORM}-\gamma^{MIN}}{\gamma^{MAX}-\gamma^{NORM}}\right)$$

where
$\gamma_t(i)$ is the capital growth rate in industry *i* in year *t*;
$EROR_t^{EQ}(i)$ is the expected equilibrium rate of return in industry *i* in year *t*;
$ROR^{NORM}(i)$ is the industry's historically normal rate of return;
$F_t(i)$ is a shift parameters that allows for vertical shifts in the capital supply curve;
γ^{NORM} is the historical normal rate of capital growth in industry *i*;
γ^{MIN} is the minimum possible rate of growth, which is determined as $-\delta(i)$. This specification ensures that investments are always nonnegative;
γ^{MAX} is the maximum possible rate of growth;
c(i) is a parameter, which measures the sensitivity of capital growth to variations in the expected equilibrium rate of return.

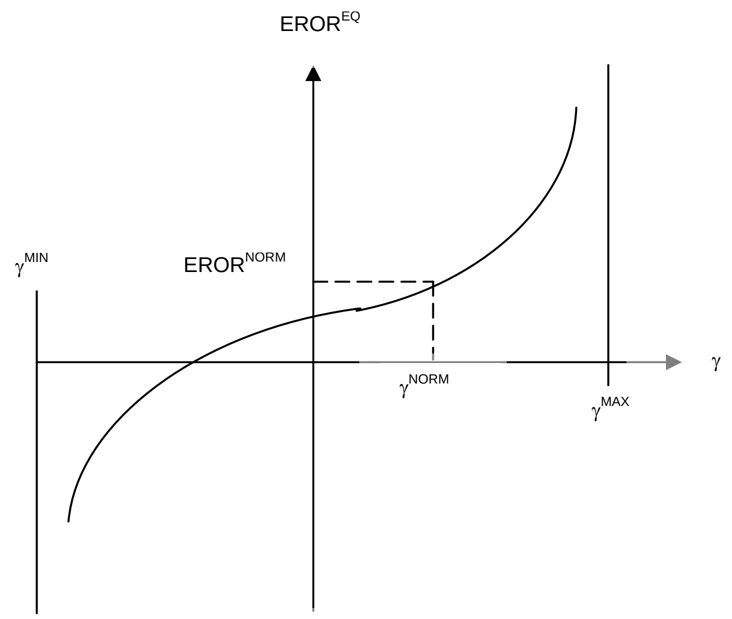
Assume that $F_t(i)$ is zero. Then the growth rate is the historically observed rate if the expected equilibrium rate of return equals the normal rate of return. For the industry to attract sufficient investment for the growth rate to exceed the normal rate, the equilibrium expected rate of return must be greater than the normal rate. Similarly, if the equilibrium expected rate of return is less than the long-term average, then investors will restrict their supply of capital to the industry below the level required to generate capital growth at the historically observed rate, cf. figure 1.

The sensitivity parameter, *c(i)*, is a function of the slope of the curve in the region where the actual growth rate equals the historically observed rate. The steeper the curve is at this point the more sensitive is investment to movements in the expected equilibrium rate of growth away from the long-term average.

If the historically normal rates of return are not identical across industries then there is risk diversification: the higher is the long-term average return, the more risky it is to invest in that industry. So, the more risky it is to invest in an industry, the higher expected rate of return is required to generate a certain rate of growth.

[3] The theory may be compared to the theory of adjustment costs according to which investment is limited by the assumption that the costs per unit of installing capital are positively related to the level of investment. Here, investment is limited by the caution of investors instead of adjustment costs.

Figure 1. Relationship between equilibrium rate of return and capital growth rate



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:

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

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*.

The expected disequilibrium rate of return is non-zero if the database does not generate a combination of the rate of return and the capital growth rate that is on the capital supply curve. In year *0* the growth rate is determined by investment in that year and capital at the start of the period. Then the capital supply curve determines the implied expected equilibrium rate of return in year *0*. However, the initial data also includes return to investment such that we can compute the initial actual rate of return. If these two rates are not identical then the initial disequilibrium rate of return is non-zero. It is assumed that this disequilibrium disappears gradually over time.

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, we assume that agents take only account of current rentals and current prices and, therefore, they expect that rental rates and prices will increase by the current rate of inflation. This specification allows a recursive solution method: the solution for year *t* can be computed from known variables in that year. Then the solution for year *t+1* can be computed from known variables in that year, etc.

Under forward looking expectations agents form rational expectations about future rentals and prices, that is, the expected rate of return is the model-consistent rate of return:

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

Hence, investment in year *t* depends on rentals and prices in year *t+1*. Consequently, the 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 using data for year *0*. 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.

2.2. Financial asset accumulation

The financial asset accumulation consists of net government debt and the economy's net holdings of foreign liabilities.

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. It is assumed that (i) interest and dividend payments accrue on the basis of the average net debt at the start and end of the year, (ii) the composition of the net debt in terms of different types of financial instruments is fixed, and (iii) transfers, interest rates, and foreign dividend rates are exogenously given, whereas the rate of return on Danish equities is calculated as a weighted average of the rates of return in all industries.

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.

2.3 Lagged adjustment process

The lagged adjustment process relates to the operation of the labour market. It allows the real wage to be sticky in the short run such that employment adjusts to accommodate this stickiness in the event of any policy change. In the long run employment is sticky and the real wage adjusts. In between, employment and the real wage both adjust.

3. **Scenarios**

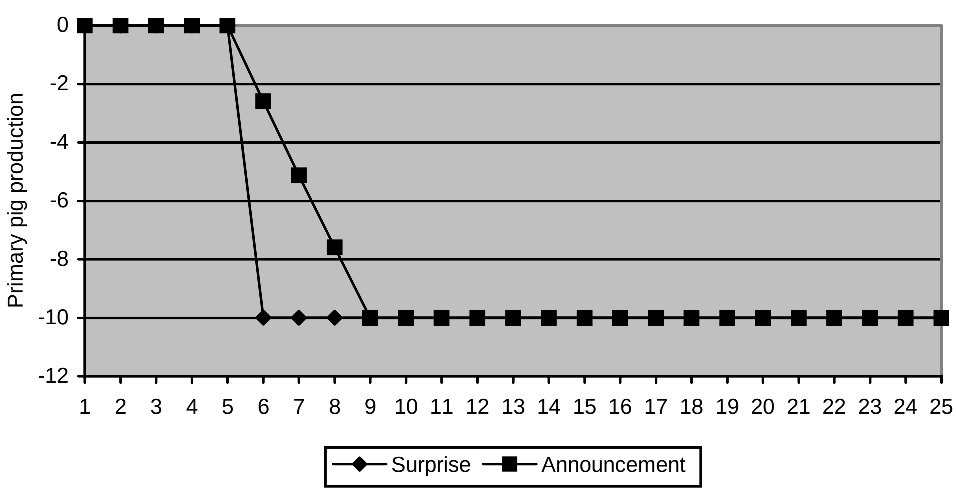
The model is solved over a 25-year time horizon and results are reported as per cent deviations from a baseline scenario. The baseline is very plain since we focus solely on the policy deviations. To allow for maximum flexibility, we model a tradable quota on the pig production such that the policy intervention limits the aggregate pig production without destroying the possibility of structural adjustment. We model the quota by exogenising the pig production and introducing an endogenous output tax. In that case the pig production is tied to the quota as long as it delivers a positive return. The quota return goes to the pig 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 simulation and onwards such that the maximum annual production from year 9 and onwards is 10 per cent below the baseline production. 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. We model this scenario by assuming static expectations such that agents do not take into account future policy changes 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 simulation. We model the scenario by imposing a gradually more restrictive quota and assuming rational expectations such that agents in early years take into account the future policy changes, cf. figure 2.

Figure 2 The scenarios, deviation from base, per cent



In both scenarios the policy change is initiated in the same year, which allows us more directly to focus on the issues of timing and announcement. Alternatively we could have analysed the impact of introducing the quota today versus announcing it today and implement it tomorrow – which from a policy perspective might be of interest – however, a comparison of the results would have been less straight forward.

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. [4]

Hence, 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 production 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

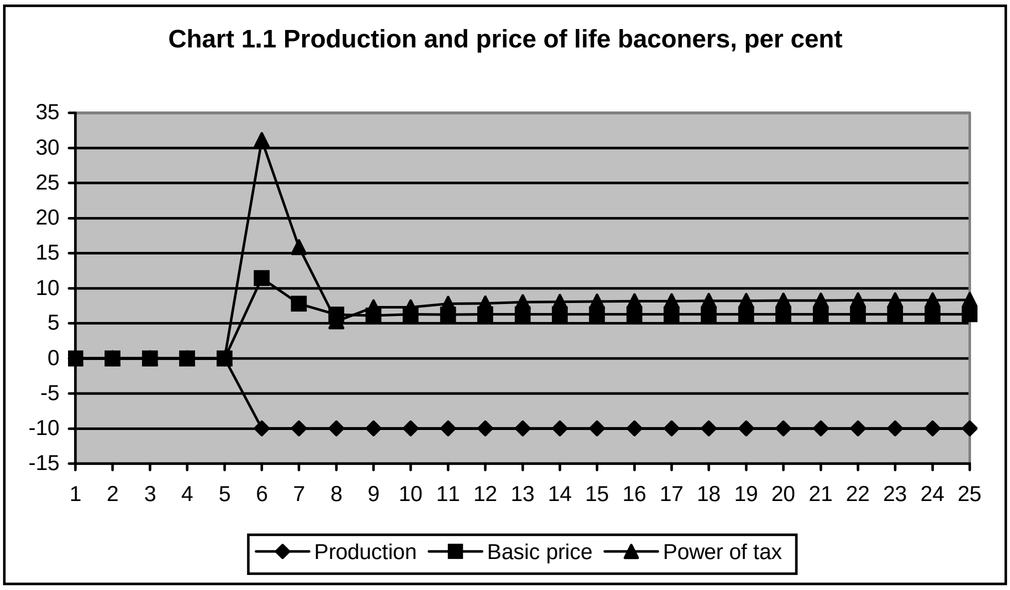
First, we discuss the results in the case of surprise implementation. We examine the effects for some key industries as well as macro effects. Then we discuss the results in the case of announcement by relating out main findings to the first scenario. Results are reported as per cent deviations from the baseline scenario.

4.1 Surprise implementation

Effects on industry levels

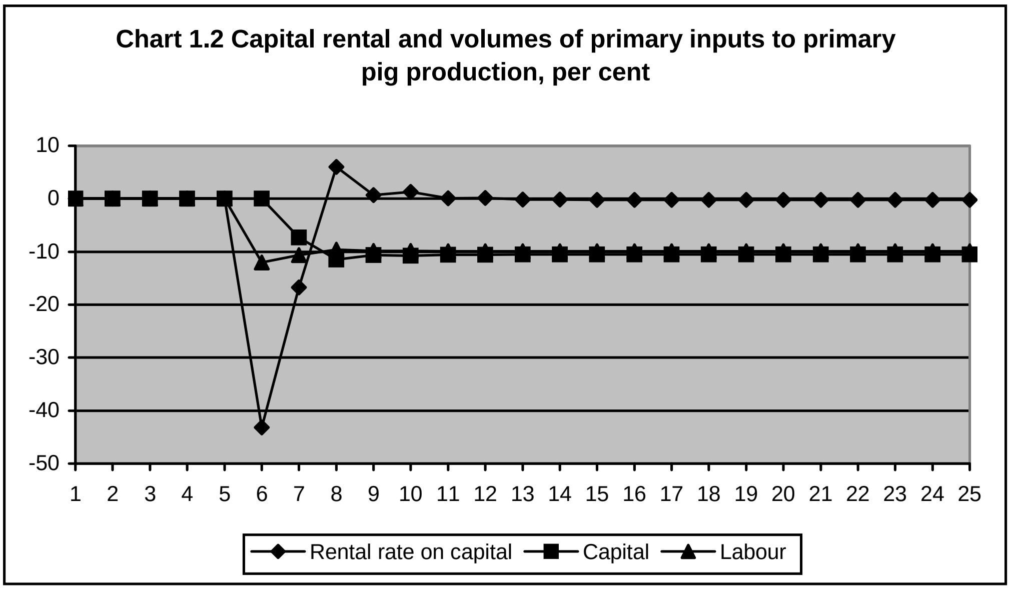
In the primary pig production industry the quota immediately lowers the production by 10 per cent compared to the base case. The power of tax required to bring about this production cut is approximately four times larger in the first year than it is at the end of the simulation period, cf. chart 1.1. This is due to the fact that the factor markets adjust over time such that the level of primary inputs available in the first year after implementation is "too large" compared to the legal level of production. Therefore, a power of tax above 30 per cent is required to keep producers within the quota level. As the level of primary inputs adjust the power of tax can decrease. In the long run the tax is passed on to the basic price of life baconers.

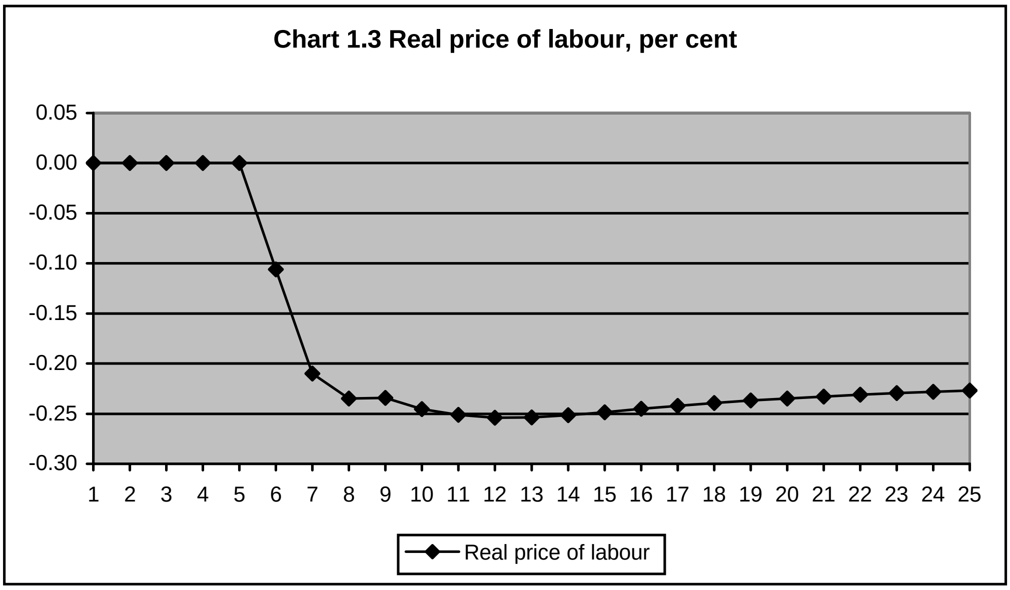
[4] Moreover, it is not possible to model a scenario where a quota that reduces production by 10 per cent compared to base is introduced once off when expectations are rational. The reason is that the model cannot handle the required fall in prices when expectations are rational. However, assuming gradual implementation in the static expectations case would not alter the main results qualitatively



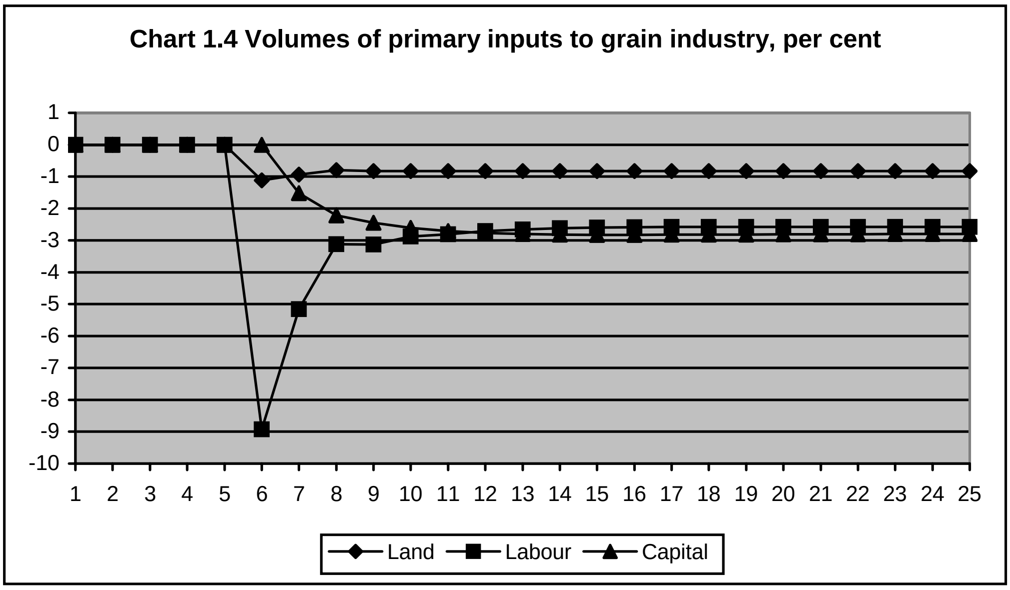
The lower production of life baconers means lower demand for inputs. But since capital is initially fixed, the rental rate of capital adjusts to clear the market. In chart 1.2 it is seen that this requires a huge adjustment. The reason for this is that the pig industry is very capital intensive such that it has an inelastic supply curve. Moreover, nearly all of pig production is sold to the pig manufacturing industry, which is very capital intensive too, such that the demand schedule facing the primary pig industry is inelastic in the short run. Hence, the quota requires a large fall in price. This is brought about by a decrease of more than 40 per cent in the capital rental. In the long run capital adjusts through adjustments in investment such that the rental rate on capital returns to the baseline level. In between we observe that an overshooting of the adjustment in investment delivers a capital rental above base in year 8 of simulation. This effect is due to the assumed expectations formation according to which agents do not take into account future price adjustments when making today's investment decisions. Hence, in year 6 and 7 agents do not anticipate that the adjustment in rental rates slows down over time. Therefore, they restrict investment so much that the rental rate exceeds base in year 8.

Due to the lagged adjustment process in the labour market the real wage does not immediately adjust fully to clear the labour market, cf. chart 1.3. In stead both the real wage and employment decrease. Since the rental rate on capital has adjusted fully to clear the capital market, the relative price of labour and capital has switched such that primary pig producers substitute from labour to capital. As both the capital rental and the price of labour adjust in the longer run, the capital-labour ratio returns to the base case level, cf. chart 1.2.

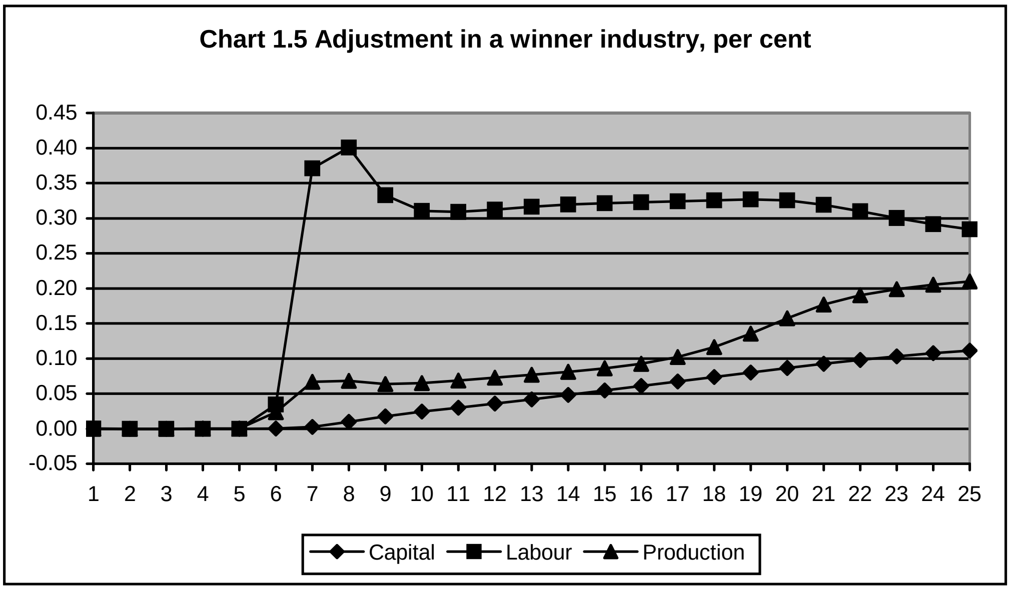




Primarily three industries loose due to the quota: the primary pig industry, the pig manufacturing industry, and the grain industry being a main input supplier to the pig industry. In these industries we see the same adjustment in factor inputs and –prices. In the grain industry the lower demand for grain also results in lower demand for land. But due to the hectare premium it does not decrease as much as the demand for other primary factors of production, cf. chart 1.4.

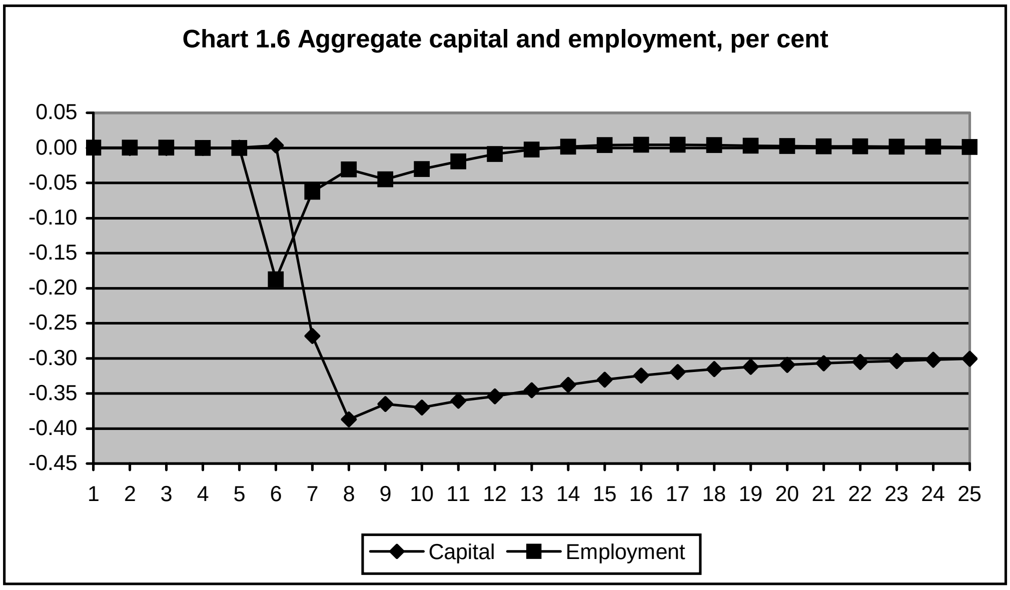


Most other industries gain through the policy intervention. The lower price on labour, land and on intermediates enable other industries to increase production at lower unit costs. Hence, the demand for capital increases such that the rental rate and thus the return to capital increase in these industries. This induces producers to switch from capital towards land and labour such that employment starts increasing and the downward pressure on the price of land is modified. In the long run further adjustments in the price of labour and rental rate on capital narrows the deviation of the capital-labour ratio from base, cf. chart 1.5.



Macro effects

The rigidity of the real wage in the short run means that not all the labour released from the pig industries and the grain industry is immediately absorbed by the winning industries. Hence, aggregate employment falls by 0.2 per cent in the first year after implementation of the quota, cf. chart 1.6. Since land is fixed and capital is initially fixed, the fall in employment generates a fall in real GDP relative to base, cf. chart 1.7.



The large fall in the rental rate on capital in the pig industries and, hence, the large fall in the rates of return on investment in those industries show impact on aggregate real investment. In chart 1.7 it is seen that investment drops 2 per cent initially. Largely due to the fall in investment, real GNE (private and public consumption plus investment) fall relative to real GDP, implying that the net volume of trade must move towards surplus. To achieve the improvement in the net volume of trade some real devaluation of the exchange rate is necessary, cf. chart 1.8. The real devaluation reduces imports and encourages exports, cf. chart 1.9.

In chart 1.7 it is seen that initially real private consumption increases above base. This is because the immediate effect of the policy change on households' disposable income is positive. Even though the primary factor returns decrease, households' disposable income increases for two reasons: the large initial quota return which goes to pig producers as personal income, and the fact that the balance of trade improves such that the net foreign debt decreases and the net external interest payments decrease. When the disposable income increases so does private consumption relative to base since the average propensity to consume is assumed to be fixed. Since public consumption moves with private consumption, public consumption increases too.

In the long run investment adjusts such that the deviations in rental rates narrow. Also, in the long run policy changes have no effect on employment, so the price of labour adjusts fully. Since the primary and secondary pig production is lowered substantially, and since both industries are very capital intensive, the overall capital-labour ratio of the economy fall compared to the base case level, cf. chart 1.6. Even though land and employment return to its base case levels, real GDP falls due to the lower capital stock, cf. chart 1.7.

Chart 1.7 Real GDP from income side, per cent

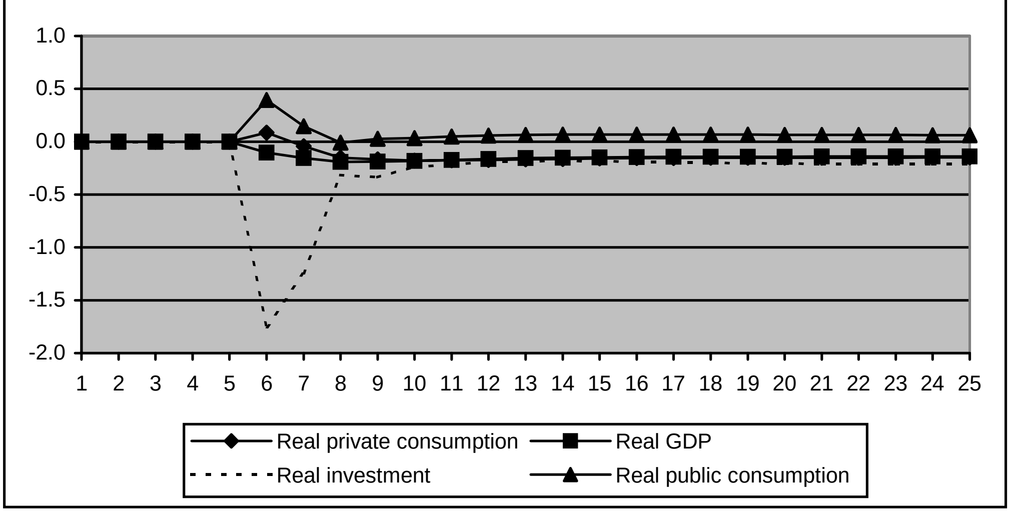
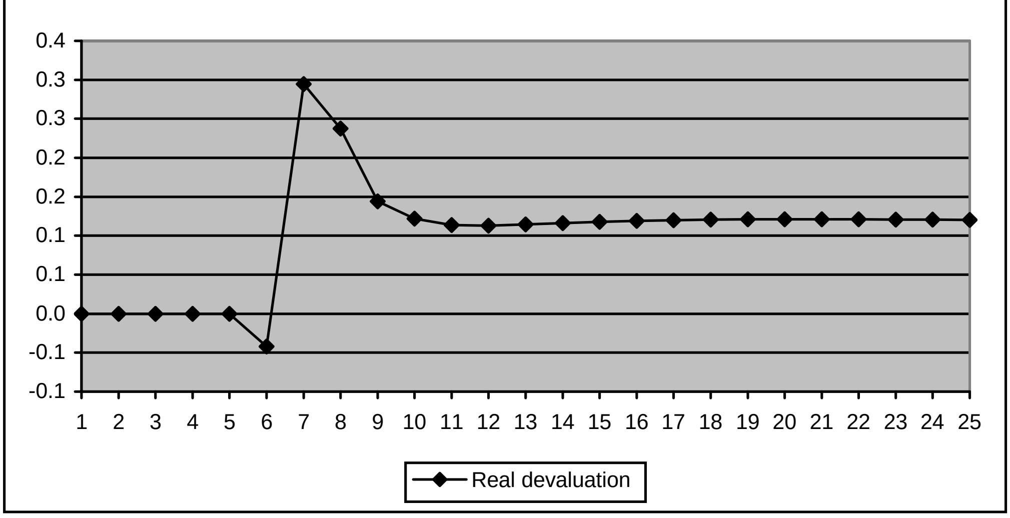
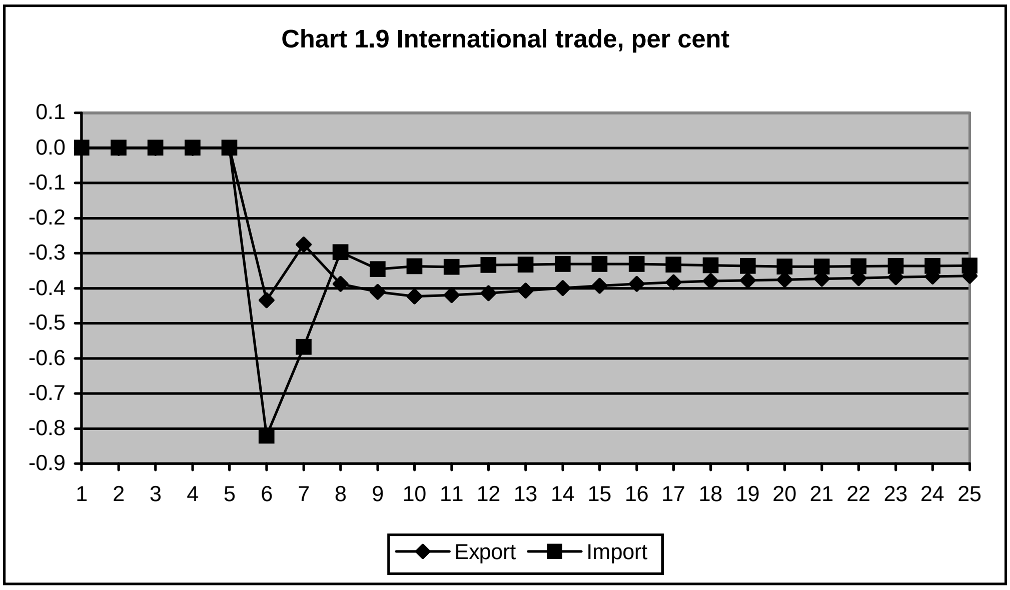


Chart 1.8 Real devaluation, per cent

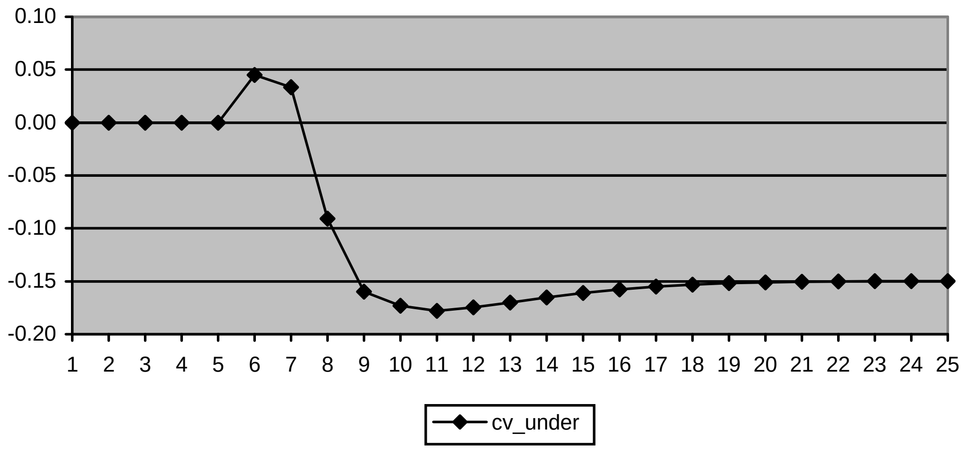




The production quota damages welfare. We employ two welfare measures, which are called *EV_OVER* and *CV_UNDER*. Both are simple measures that have the advantage of not relying on a specific household utility function. Equivalent variation can be thought of as the amount of additional income that consumers 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 1.10 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. Initially, we see the opposite development, which is ascribed to the aforementioned initial increase in households' disposable income.

Chart 1.10 Welfare, per cent of aggregate consumption in the base case forecast

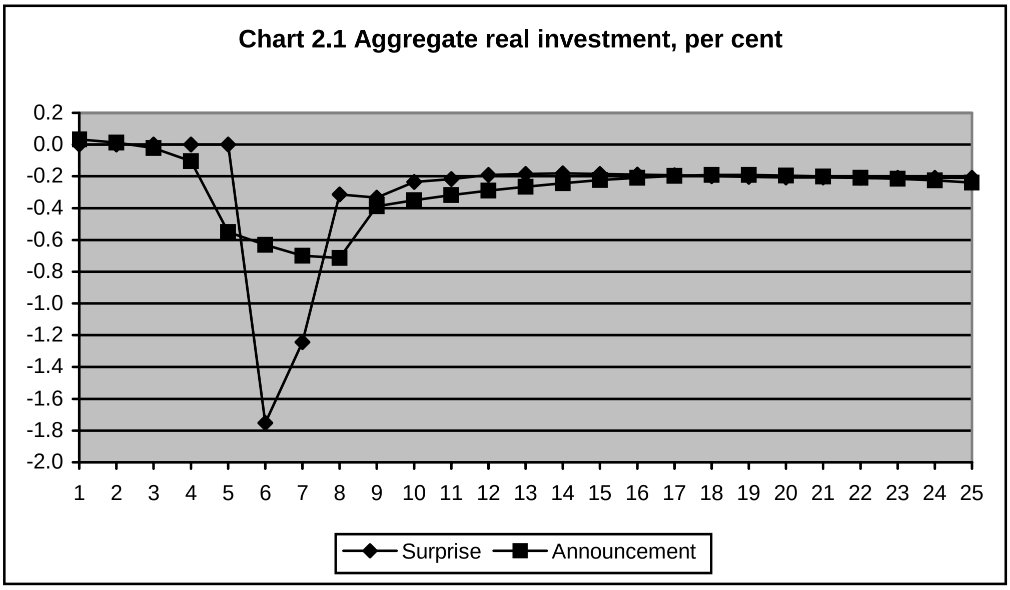


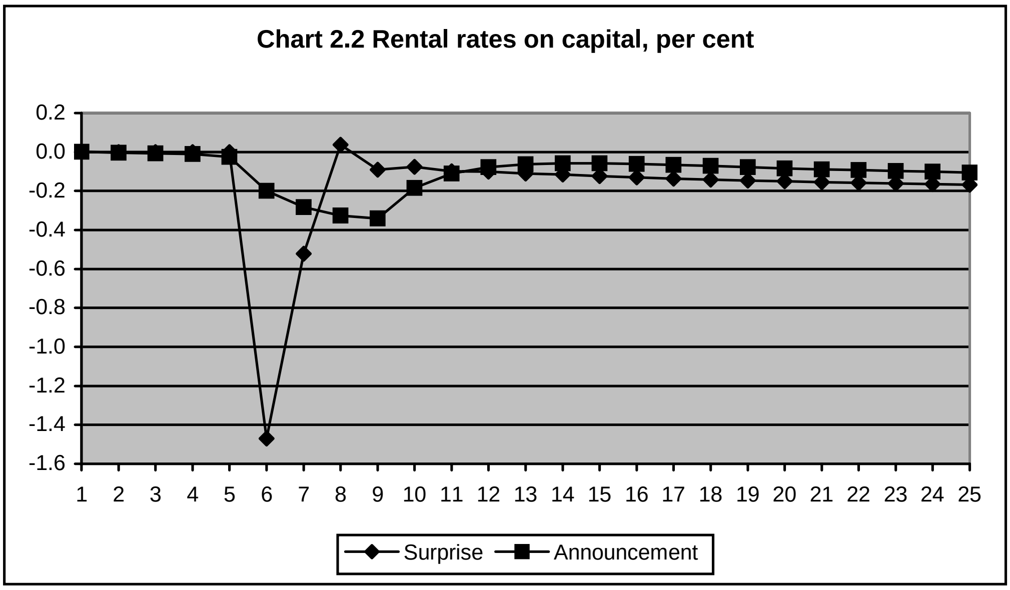
4.2 Announcement

In this scenario we switch both expectations formations and method of implementation by assuming that agents form rational expectations, and implementing the quota gradually over four years. We interpret the scenario as if a quota is announced at the start of 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 the adjustment path and the long run effects.

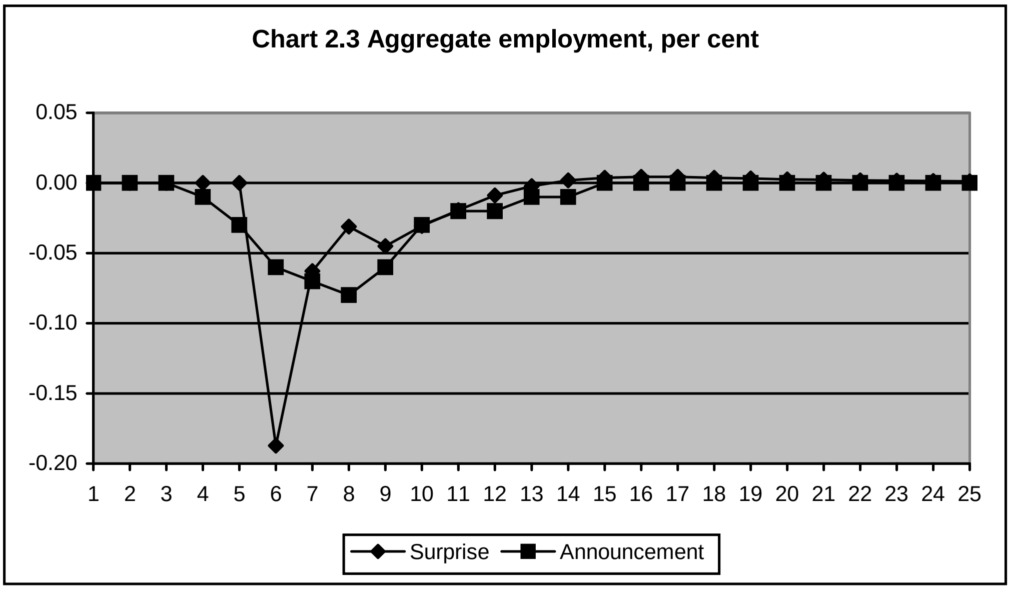
In chart 2.1 it is seen that investors' behaviour adjust to the future change in policy from the initial year of simulation. From the outset investors take into account that the quota induces final goods producers to demand less capital such that the future rental rates and, therefore, rates of return on investment, decrease. This ensures a smoother path of investment at the aggregate level as well as at industrial level than in the previous scenario. Therefore, adjustment does not require the rental rates on capital to decrease as sharply as in the surprise implementation scenario, and we observe more smooth adjustments in capital rentals in this scenario, cf. chart 2.2. As investors anticipate future adjustments in prices and rentals correctly there is no overshooting of adjustment in this scenario.

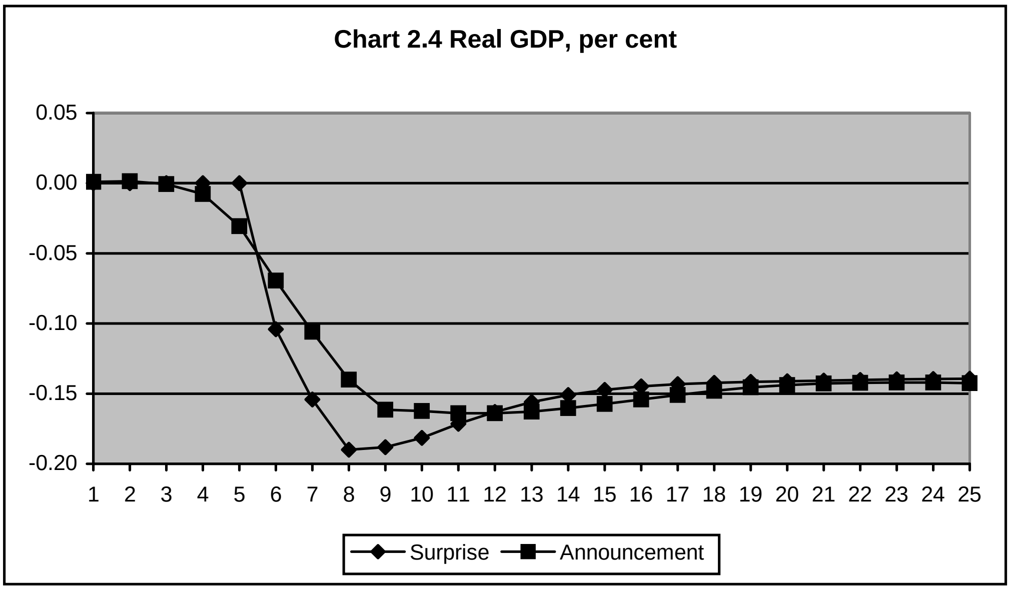
It is seen that even though investors anticipate correctly future prices and rentals there is a drop in investment in the medium term above the long-term level. This is due to the fact that investors are assumed to own capital in only one period and then sell it to other investors. Hence, what matter for today's investment decision are the prices and rentals tomorrow but not directly future prices and rentals. However, even if investors were assumed to own capital indefinitely we would observe some overshooting of investment in the medium term if investors discount the future.



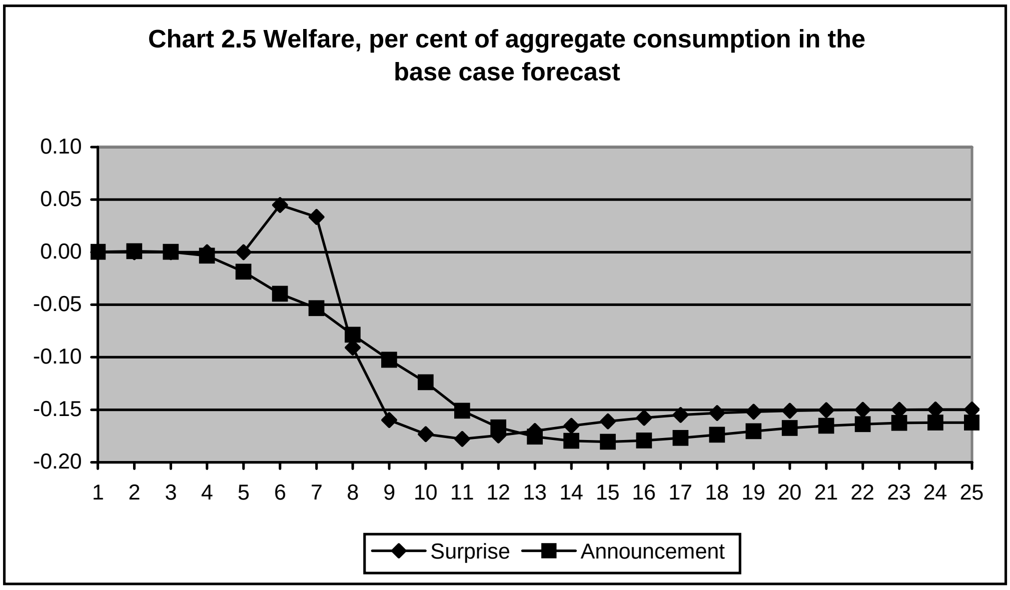


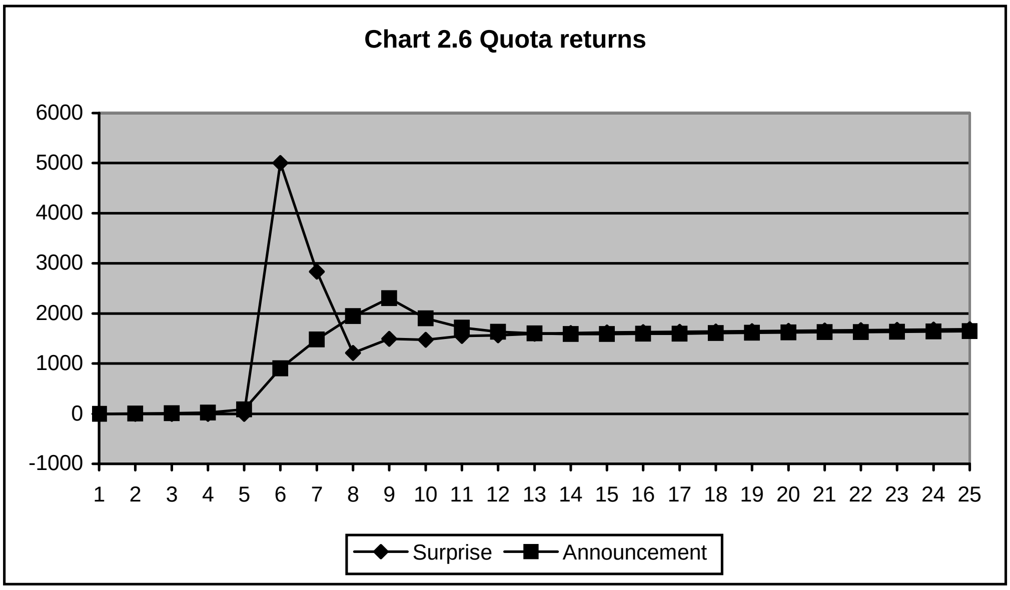
As producers start to adjust production so does their input demands. Hence, the demand for labour decreases from the start of the simulation, cf. chart 2.3. But since the wage rate adjusts only slowly there are some temporary effects of the policy change on aggregate employment. In the longer run the real wage adjusts so the two scenarios delivers identical aggregate employment levels in the long run. It is seen 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. Therefore, we observe a drop in real GDP in year 3 and 4 in the announcement scenario compared to the previous scenario, cf. chart 2.4. But in the surprise implementation scenario, real GDP decreases to a lower level in year 6 due to the huge drop in investment in the first year after the policy change.





The announcement scenario implies a more smooth development of welfare too, and the initial increase is not observed, cf. chart 2.5. The smoothness of adjustment in the announcement scenario prevents the initial improvement in the income balance and large quota return from showing impact on the disposable income. Chart 2.6 shows the adjustment in the quota return. The adjustment path of the income balance is very similar to that of the quota return such that both the income balance and the quota return develop more smoothly. Therefore, in the entire period the negative effects of the returns to primary factors dominate the positive effects from the income balance and the quota return.





Summing up: The 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 macro-economic 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.

Reducing the production of pigs by 10 per cent - compared with the base case - leads to a decline in the export of pork meat by 13 per cent. However, as the export of other commodities increase somewhat due to a 0.22 and 0.17 per cent lower real price of labour and capital, respectively, the total real exports decline by 0.36 per cent. The environmental inspired policy change also leads to a 0.21 per cent lower investments and a 0.3 per cent lower level of the real capital stock in the long run. The real GDP and real private consumption decline by 0.14 and 0.15 per cent, respectively, and the total real import falls by 0.33 per cent. The overall lower level of activity in the land using sectors leads to a 7 per cent fall in the price of land.

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

Real GDP	-0.14
Real private consumption	-0.15
Real public consumption	0.06
Real investment	-0.21
Real export	-0.36
Real import	-0.33
Real capital stock	-0.30
Terms of trade	0.10
GDP deflator	-0.02
Price of capital	-0.07
Rental rate on capital	-0.17
Price of labour	-0.22
Price of land	-6.97

Note: The results shown are from the “Surprise implementation” scenario. The results generated in the “Announcement” scenario are similar.

5. Conclusions

We have addressed 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. However, in the long run the two scenario deliver similar economic effects.

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? 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 still 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 earlier 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) finds that it is preferable to implement a tariff cut without warning. The reason for this result is that the tax cut is announced at the start of simulation and implemented in year 12. Due to the cut, 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. Hence, the main reason why Malakellis' and our conclusions differ is the timing of implementation within the scenarios. While Malakellis compare two scenarios where the policy change takes place in year 12 and in the initial year, respectively, we compare two scenarios where the policy change is initiated in the same year.

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. In short time we will be able to conduct dynamic analyses with the 1995 input/output data. Also, we are in the process of developing a realistic base case. In the longer run the agenda includes refinement of the households' expenditure system, the treatment of external debt and the equations governing exports and imports. With some of these improvements in place, the model will, e.g., be used to investigate alternative strategies for reducing the pig production as well as the adjustment problems of converting conventional forming into organic farming.

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