Chapter 9

Investigation of key individual time series and their policy implications

This chapter is the core of the dissertation. Here, we investigate the behavior of key macro and sectoral variables during the 1990s, so as to understand the behavior of the economy in response to various disturbances.

This chapter is the foundation of the subsequent analysis: In Chapter 10, we sketch out some accounting that follows from this chapter's analysis; then, after another exploratory chapter (Ch. 11), we devote Chapter 12 to comparing the insights gained to the common stories about structural adjustment in Ghana and common assumptions of models of structural adjustment that we had discussed in Chapters 3 and 4, respectively. Finally, in Chapter 13 we use the discussion of Chapter 12 as a base for explaining the behavior of the Ghanaian economy during the 1990s and making policy suggestions.

The investigation of data in this chapter is divided into two sections. Section 9.2 looks at the supply side of the product markets, namely the validity of the Incremental Input-Output Ratio, the determinants of investment, and the existence of price substitution between production for the domestic market vs. for export. Section 9.3 investigates the demand side of the product markets, namely at the sources of demand injections, the savings ratio, the consumption demand, and the price elasticity of substitution between imports and domestically produced goods. Most of the data (except prices) used in these sections is available on a yearly basis, giving us a total of 12 data points per variable. This is barely enough to make reliable statistical inferences; Section 9.1 discusses our way of addressing that.

As this chapter goes through quite a lot of data, each section is followed by a section summary as an orientation help to the reader.

9.1 A method for dealing with short data series

While for the financial series, twelve years of monthly data allow us to use a variety of statistical techniques to analyze the data, the situation is more constrained for real macro and sectoral data. With such short time series, there is a high danger of spurious regression, that is, of equations fitting well by chance rather than as an expression of an underlying causal relationship.

We address this in the following manner: data from 1990 until 1997 are used for calibration of the equations, and data from 1998 until 2001 to validate it. Thus, if the equation that fits well in the calibration period also performs well during the validation years, we conclude that it reflects a causal relationship; otherwise, we discard it.

This procedure is also useful to get a feeling for how good the model could be as an instrument of prediction. Once the equations have been validated in the manner described above, one could then re-calibrate them to the data for the whole twelve years and use them to predict behavior for 2002 onwards. The ability of the equation to predict data for 1998-2001 using only data for 1990-1997 could then be regarded as an indicator of its likely ability to predict future behavior for which no validation data is available. While doing that is outside of the scope of the present dissertation, it will be useful in further work on the issue.

All equations tested attempt to explain the independent variable (for example, share of imports in consumption of manufactured goods) by means of a (possibly time-lagged) dependent variable (for example, a relative price) with a possible inclusion of a time trend. Besides using the non-lagged value, we try out a fixed lag (using the value of the independent variable a fixed time, say three months ago), and an exponential-distributed lag (a weighted average with the weight decaying exponentially as a function of lag). This gives us three options for lag specification; an independent decision is whether to include a time trend or not, resulting in six possible equations. The coefficients to be optimized are an intercept, the coefficient of the independent variable, a time trend where included, and a time constant where a time lag is included.

To interpret the time trend and time constant coefficients, one should note that the unit of time here is one month, thus a time constant of 3 means a lag time of 3 months, and a time trend of 0.05 means 0.05 per month thus .6 per year.

Since the real-side data are available yearly, and some price series are available monthly, in such cases the equation was formulated using monthly data, and the resulting forecast was then summed up at yearly intervals to enable comparison with the yearly data. In the cases where the independent data was available yearly, interpolation was used to compute lags that were not multiples of a year.

We estimate the equation by minimizing the squared error of the equation over the estimation period. As the time lags are a nonlinear function of the lag time, nonlinear estimation is used.

To make it easier to compare prediction errors in different variables, we first estimate a constant approximation to the independent variable during the estimation period (1990-1997), and then use it to compute R^2 measures for both the estimation and the validation period (the latter being 1998-2001) in the standard way: suppose the error of the constant approximation is e_c, and the error of another approximation over the same period is e. Then the R^2 over that period is defined as $R^2 = 1 - e/e_c$. Note that while inside the estimation period adding another variable always leads to an improved R^2 in the usual manner, the extended equation may well (and often does) have worse fit than a constant over the validation period. Thus the R^2 is quite often negative over the validation period.

Another criterium for equation validity is the value of the time constant that describes the lag with which the independent variable influences the dependent variable. We limit the lag to 36 months, in our view an ample margin to allow changes in the independent variable to have their impact. If the value of the time constant from the optimization process actually hits the 36-month maximum, we take that as a sign of a spurious regression and disregard that particular equation. This practice is confirmed by the fact that such equations typically also have quite high errors in the validation period.

After selecting the equation that, when estimated over the estimation period, does best at predicting the validation period behavior, and is thus presumably the best causal description of the independent variable, we re-estimate it for the whole period 1990-2001.

The results are summarized in a table for each of the variables inspected. The best equation's name is framed and the corresponding constant values are in bold, as are the constants for that equation re-estimated using data from the whole time period. If the estimated value of a time constant equals 36, the constants of that equation are set in slanted type to indicate that they're suspect.

To provide visual information over the behavior of the time series investigated as well as the predictions thereof, we include a graph with each table. There, the diamonds are the data points being approximated, the thin lines are all the different equations estimated over the estimation period, and the thick blue line is the best equation being estimated over the whole period.

Having explained the methodology, we are now ready to discuss the individual results.

9.2 Supply Side

9.2.1 Incremental Capital-Output Ratio

The first thing we test is the infamous Incremental Capital-Output Ratio or ICOR, that is the assumption that new investment translates in strict proportion into increases in output as $\Delta y = \sigma \Delta K = \sigma I$, with σ being the actual ICOR. This can be reformulated as

$$\frac{\Delta y}{y} = \sigma \frac{I}{y}$$

, that is the growth rate of GDP is proportional to ratio of investment to GDP, or also as $\Delta y / I = \sigma$, that is the growth rate of GDP divided by investment is a constant.

We first test the second formulation. The time series $\Delta y / I$ turns out to have a mean of .626 and a standard deviation of .501, thus a t-ratio of 1.25 - not significant even at 10% level. If we use *last year's* investment to allow for an installation lag, the t-value is 1.33 - also not significant.

Finally, we regress the rate of growth of GDP on ratio of investment to GDP, using both the this year's and last year's investment at the same time as two explanatory variables. We get an R^2 of 12% and neither of the explanatory variables is significant at the 10% level (t-values of .019 and .698, respectively).

We thus conclude that in accordance with the references quoted in our discussion of ICOR in Chapter 4, the incremental capital-output ratio is not constant at all.

9.2.2 Real Investment

We try to predict the ration of investment to GDP in real terms as a function of interest rates on treasury bills and the relative price of imported vs. domestically produced manufactured goods. The latter is a proxy for return to investment as most capital equipment is imported, and most of it is used in domestic manufacturing.

As in most of the equations investigated in this chapter, we take the natural logarithm of both the dependent and the independent variable, so that the coefficients can be interpreted as dimensionless elasticities. We make an exception for the interest rate.

This equation does very badly at prediction during the validation period, with none of the formulation able to out-perform the constant approximation. However, we can look at patterns in estimated coefficients, and try to draw conclusions from these.

Industry Imports	Intercept	Time Trend	Relative Price Elasticity	Relative Price Time Constant	Interest rate elasticity	Interest rate Time Constant	Estimation R^2	Validation R^2
Constant only	-2.23						0%	0%
Exponential delay	*0.09*	*-0.0161*	*-4.11*	*33.79*	*0.11*	36	*98%*	*-2815%*
Fixed delay	-0.18	-0.0081	-1.38	7.5	-0.01	35.74	91%	-8951%
No delay	-0.36	-0.0052	-1.02		-0.02		79%	-8422%
Exponential delay,no trend	0.26		-1.34	3.49	-0.03	1	74%	-4314%
Fixed delay, no trend	.268		-1.34	3.84	-0.034	1	-74%	-4472%
No delay, no trend	0.27		-1.34		-0.034		72%	-5344%
Best equation estimated on the whole interval	-1.59(.31)		-0.53(.47)	7.89	-0.017(.0086)	1.00	-2%	

Table 9.1: *Ratio of investment to GDP as function of relative price of imports and of interest rates*

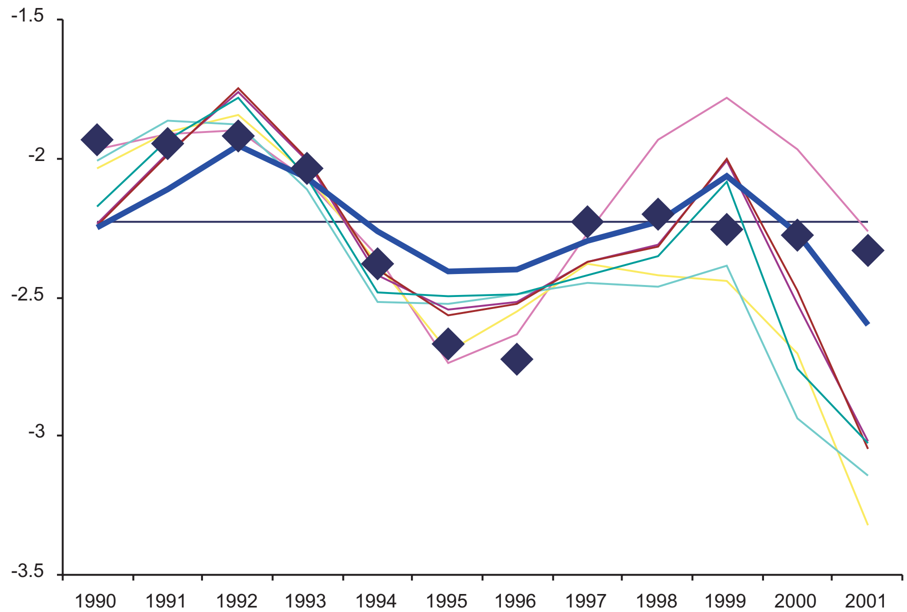


Figure 9.1: *Ratio of Investment to GDP (log scale)*

What we see is firstly, a falling time trend that has disturbing implications for the overall capital stock in the country. Second, the relative price elasticity is pretty consistently slightly above -1, implying a high degree of responsiveness to relative prices. In particular, in the case of a currency depreciation, investment could be expected to contract quite strongly, so that it would shrink even in nominal terms. The response to interest rates corresponds to investment over GDP shrinking by one to four percent (not percentage points) for each percentage point increase in interest rates - a substantial response if we consider that the interest rates have ranged between 10% and 50%.

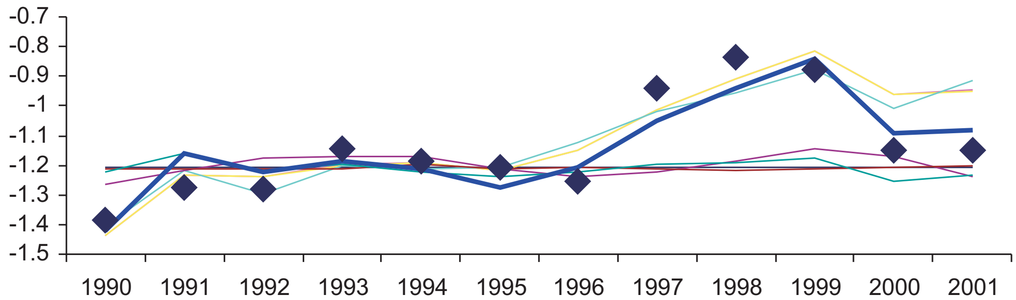
9.2.3 Ratio of exports to nontraded goods in industrial production

In comparison to investment, we are quite successful at predicting the ratio

of exports to nontraded goods in industrial production. The following features leap to the eye: firstly, equations that include a time trend do vastly better in the validation period than those that do not. This can be understood as reflecting the opening up of the economy over the 1990s; all the more so as the time trend decreases if we estimate the equation for the whole 12 years of the 1990-2001 period. That can be seen as corresponding to a slowing-down of the opening-up process in the second half of the period after the drastic trade reforms have had their initial impact during the first half.

A more surprising result is that the relative price elasticity turns out to be consistently negative, and is actually greater in absolute value if we use the whole time period. This is at first glance surprising as this means that higher prices of exports relative to nontraded manufactured goods lead to an *increase* of nontraded manufactured goods production compared to export production. This is completely contrary to what one would expect from a traditional neoclassical supply-constrained productivity-frontier profit-optimizing model.

However, it is fully consistent with a demand-driven nontraded manufacturing sector, as common e.g. in structuralist models: if exports prices rise relative to domestic manufactures, this



	Intercept	Time Trend	Elasticity	Time Constant	Estimation R^2	Validation R^2
Constant only	-1.21				0%	0%
Exponential delay	**-1.30**	**0.0042**	**-0.74**	**4.25**	**79%**	**67%**
Fixed delay	**-1.30**	**0.0042**	**-0.73**	**4.47**	**79%**	**67%**
No delay	-1.34	0.0039	-0.42		75%	65%
Exponential delay, no trend	*-0.98*		*-1.11*	*36*	*7%*	*21%*
Fixed delay, no trend	*-1.20*		*-0.05*	*35*	*0%*	*-3%*
No delay, no trend	-1.17		-0.19		4%	9%
Best equation estimated on the whole interval	**-1.20 (0.06)**	**0.0033 (0.0005)**	**-1.00 (0.23)**	**3.67**	**98%**	

Table 9.2: *Ratio of exports to nontraded goods in industrial production as function of relative price*

means an increase in income when measured in terms of domestic manufactures, and thus increased demand for the latter, and thus increased production thereof. The fact that the elasticity is higher in absolute value if we estimate the equation using the whole period rather than just 1990-1998 is consistent with this interpretation: during the second half of the period, exports were a larger share of the economy, and thus we'd expect this effect to be stronger, as it in fact is.

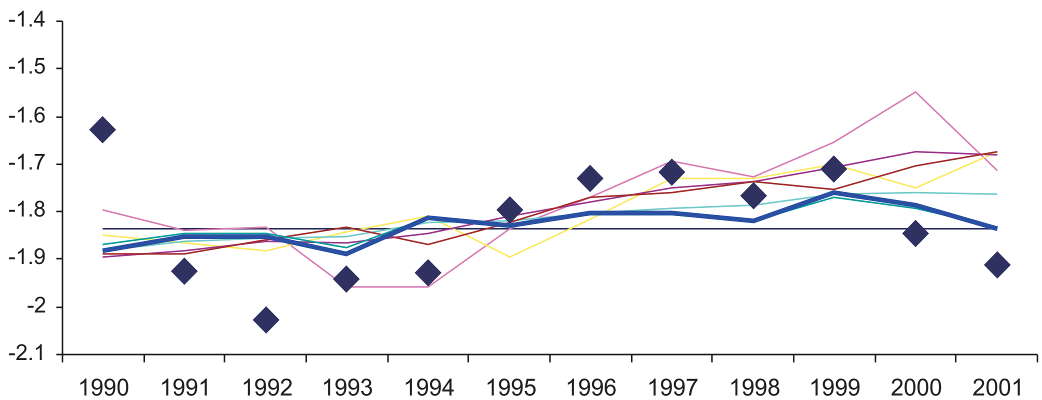
This conclusion is also corroborated by separating out mining exports (virtually all mining output is exported) from the rest of industrial exports (table not reproduced here). As mining has a completely separate capital stock from the rest of the industry, one would expect the substitution effects between nontraded and export production to become more pronounced if one excludes mining exports. However, upon excluding mining the equation fit became much worse (though the price elasticity remained negative) - exactly what one would expect upon excluding an important injection if nontraded industry output is demand-driven.

We can thus conclude that the nontraded manufacturing output is demand-determined.

9.2.4 Ratio of exports to nontraded goods in agricultural production

The picture for agriculture is quite different from that for industry. Firstly, the time trend in the ratio of exports to nontraded production is unstable over different formulations, but largely negative. The reason for this is probably that while nontraded production is expanding along with total area under cultivation (more on that below), far and away the only export crop is cocoa, and its production is restricted to forested areas, whose total area is shrinking.

The other result is a uniformly positive price elasticity of substitution. Its values vary between



	Intercept	Time Trend	Elasticity	Time Constant	Estimation R^2	Validation R^2
Constant only	-1.84				0%	0%
Exponential delay	*-1.85*	*-0.0098*	*3.28*	*36*	*42%*	*-404%*
Fixed delay	-1.87	-0.0014	0.71	30	14%	-155%
No delay	-1.89	0.0008	0.05		5%	-23%
Exponential delay, no trend	*-1.92*		*0.51*	*36*	*14%*	*-219%*
Fixed delay, no trend	-1.91		0.37	18	13%	-198%
No delay, no trend	**-1.88**		**0.15**		**4%**	**42%**
Best equation estimated on the whole interval	**-1.99 (0.05)**		**0.42 (0.15)**		**10%**	

Table 9.3: *Ratio of exports to nontraded goods in agricultural production as function of relative price*

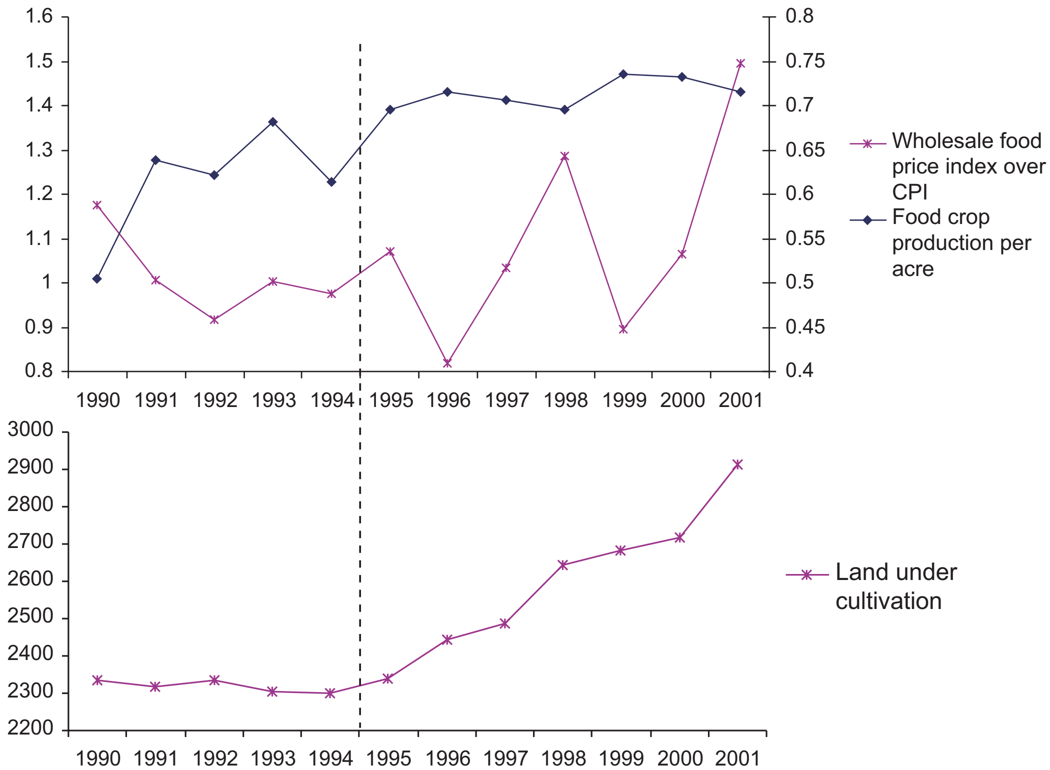


Figure 9.2: *Food crop production, wholesale price of food crops relative to the CPI and land area under cultivation*

.71 and .15, but the equation with best fit in the validation period (actually the only one to outperform the constant) has a price elasticity of .15, which changes to .42 when the same equation is estimated over the whole period. This is not implausible, as cocoa is an embedded crop and the lifetime of a tree is several years. Thus while a farmer might devote differing amounts of effort to tending the trees during different years, this doesn't lead to a price response nearly as strong as one would have if cocoa competed with food crops for scarce soil.

The positive price elasticity of substitution between exports and nontraded crops indicates a supply-constrained sector where production allocation decisions are made on the basis of relative price. Let us examine the data for the agricultural sector a little closer to see whether the supply constraint hypothesis can be corroborated.

9.2.5 Behavior of the Agricultural Sector

Let us consider three data variables: first, the ratio of the wholesale food price index (average over the major food crops) to the Consumer Price Index - a measure of the relative price of food crops; second, total food crop production per acre, and finally, total land area under cultivation (Figure 9.2).

We see that a clear change in behavior sets in at about the middle of our period, in year 1995 (the two periods are separated by the dotted line). Prior to 1995, land area under cultivation is virtually constant, and food price moves in the same direction as production. That indicates a demand-driven regime (apart from 1990 which must have been an exceptionally bad harvest).

However, from 1995 onwards, the area under cultivation grows steadily, and decreases in production (due to adverse weather conditions) are accompanied by an *increase* in price, indicating a supply-constrained regime. It thus seems likely that around 1995, population growth has caught up with the country's capacity to supply food crops, so that the agricultural sector has switched from a demand-driven to a supply-constrained regime.

Such a regime switch would also explain the bad fit of the equations, as well as the somewhat surprising fact that the fit of the best equation was actually better for the validation period ($R^2 = 42\%$) than for the estimation period ($R^2 = 4\%$) - the reason for the latter being that the supply-constrained mode represented by the positive price elasticity did not kick in before 1995.

Thus we can conclude that as indicated by all the available data, agricultural production for domestic use has hit a binding supply constraint around year 1995.

Section Summary

This section has investigated some important relationships related to the supply side of the product markets. We began by testing the venerable Incremental Capital Output Ratio, and found it to be as devoid of factual support as was the case in all previous research on the issue.

Then, we turned to the investment-to-GDP ratio as function of the relative price of domestic manufactures to imports, as well as of the interest rate on treasury bills. The performance of all equations was quite poor during the validation period (perhaps not surprising, as investment is notorious for being hard to predict); still, the signs and even values of the estimated coefficients were quite stable, and indicated an elasticity larger than one with respect to the relative price of imported vs. domestic manufactures, and a response of one to four percent to each percentage point of interest rates.

Finally, investigating the reaction to relative price of exports vs. goods produced for the domestic market showed drastically different behavior across sectors. In industry, the data strongly indicated that production for domestic market was demand-driven. In the case of agriculture, the data showed a change of regime in the middle of the period under investigation, as the growing population pushed the sector's capacity to supply food crops, so that the sector was clearly supply-constrained from year 1995 onwards.

9.3 Demand Side

9.3.1 Demand Injection Decomposition

As we turn to the demand side of the product markets, the first thing we look at are the sources of injections and leakages in the economy. The simplest way to look at them is to plot each institution's net savings over time (Figure 9.3), as net savings represents the difference between the injection and the leakage that are provided by the institution in question.

Another way to represent the same data is the Taylor decomposition (discussed in detail in Berg and Taylor [2000]). That is defined as follows: Suppose GDP is completely demand driven. By diving each institution's income by total GDP, we get its 'leakage ratio'. That would be the savings ratio for the private sector, the overall tax ratio for the government, etc. By comparing that with that same institution's demand, we can see what the GDP would be like if the only leakage and injection were due to that institution. It is straightforward to show that the actual GDP is a weighted average of these what-if GDPs (derivation is given in Berg and Taylor [2000]). This representation is shown in Figure 9.4.

Both these figures show the same pattern, namely that the government was the major driver of the economy throughout the period. It is perhaps not surprising in a small poor developing country such as Ghana to see that the rest of the world is a net drain on demand, even after accounting for foreign aid inflows; nor is it a big surprise to see that interest payments on government debt (that's the main source of the deposit money banks' income) is a comparable drain on demand. What is somewhat more surprising is that the private sector is likewise a net demand sink, with private savings exceeding private investment throughout. This would seem to imply that investment is not constrained by availability of savings. Thus we see that to the extent that output was demand-determined, government was the major driver of economic growth. We have seen in the previous section that domestic manufacturing production is in fact demand-driven. Although there is no data available for services, services are quite likely demand-driven as well due to the nature of the sector. Thus at least half of GDP is likely due to demand-driven sectors, and therefore government deficit reduction is likely to have strong recessionary impacts. We will return to this line of thought in Chapter 12.

9.3.2 Net Private Savings

Here we attempt to explain net private savings (that is savings minus investment) as a share of private disposable income, as a function of the treasury bill interest rate. Note that our estimate of net private savings is fairly reliable, as it is directly derived from monthly financial stock data.

There are two things worth observing here. First, net savings is more stable than investment, suggesting a flexible savings ratio that accommodates investment demand. Secondly, interest rates appear to have no predictive power whatsoever in explaining its variation, which is somewhat surprising, as theory predicts that increases in interest rates should decrease investment and increase savings, thus increasing net savings.

For modeling purposes, this implies that it would make sense to model total private demand and then allocate investment and consumption out of that total, rather than define separate investment and consumption demand functions.

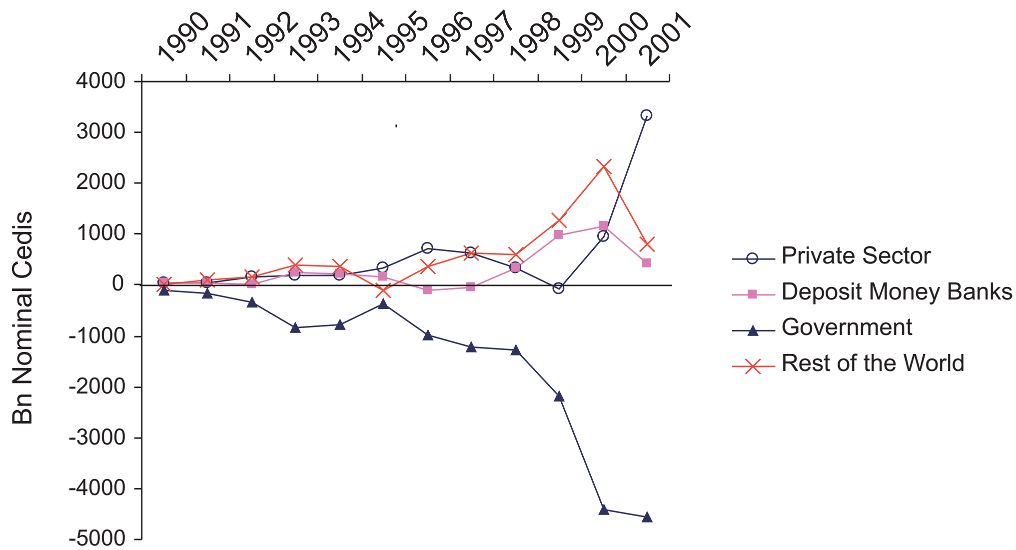


Figure 9.3: *Net Lending By Institution*

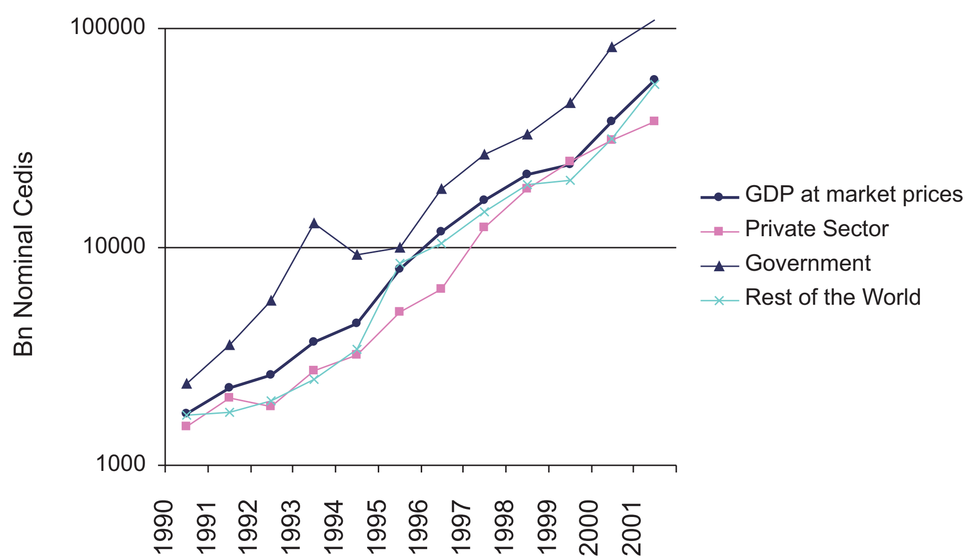
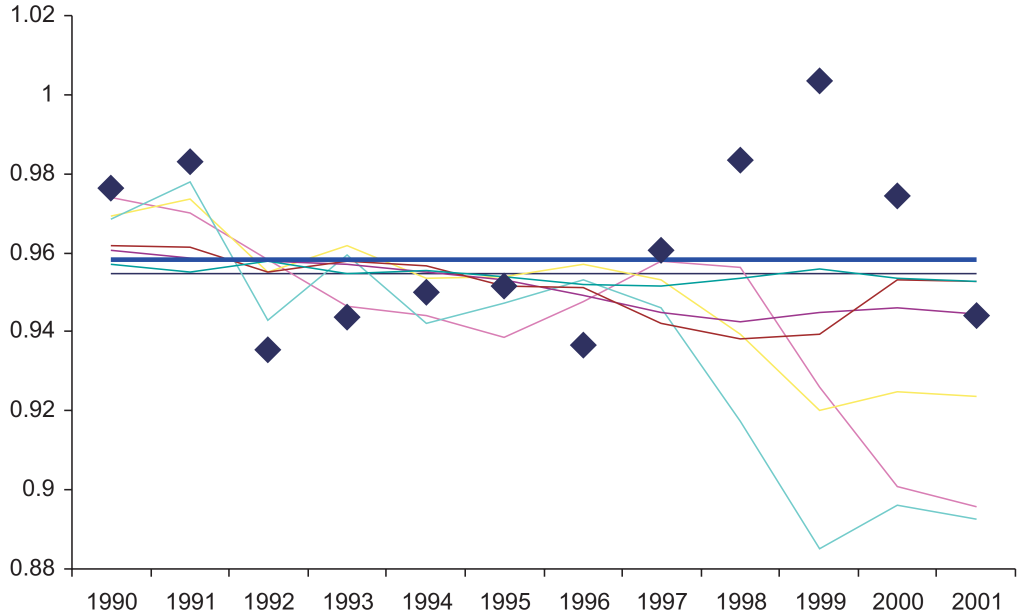
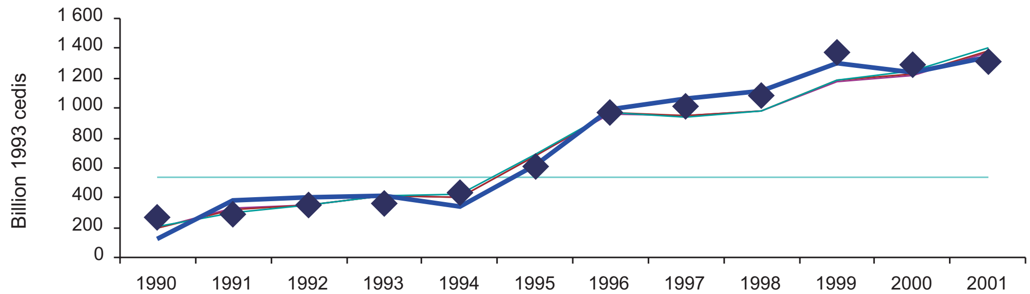


Figure 9.4: *Taylor Decomposition of Demand Injections*



Industry Imports	Intercept	Time Trend	Elasticity	Time Constant	Estimation R^2	Validation R^2
Constant only	0.95				0%	0%
Exponential delay	*0.85*	*-0.0014*	*0.0063*	*36*	*52%*	*-554%*
Fixed delay	0.95	-0.0005	0.0010	1	38%	-269%
No delay	0.93	-0.0009	0.0020		54%	-908%
Exponential delay, no trend	*0.98*		*-0.0010*	*36*	*10%*	*-85%*
Fixed delay, no trend	0.98		-0.0009	18	14%	-92%
No delay, no trend	0.96		-0.0002		0%	0%
Best equation estimated on the whole interval	0.96 (0.006)		0 (0.0007)		3%	

Table 9.4: *Private consumption plus investment as share of private disposable income*



	Intercept	Coefficient of consumption	Elasticity	Time Constant	Estimation R^2	Validation R^2
Constant only	537				0%	0%
Exponential delay	-992	1.28	-0.73	1.09	97%	97%
Fixed delay	-1056	1.51	0.94	2.35	97%	95%
No delay	**-964**	**1.16**	**-0.61**		**97%**	**97%**
Best equation estimated on the whole interval	**-941**	**1.06 (0.14)**	**-0.51 (0.14)**		**98%**	

Table 9.5: *Consumption of industrial goods as function of total consumption and relative price*

9.3.3 Consumption Function

If we follow the logic of the previous sections, then to fully specify the private consumption demand by sector it is sufficient to specify consumption of nontraded industrial goods. Total private demand as a share of private disposable income is fairly stable, nontraded agricultural goods are supply-determined, and after specifying the investment function we can take demand for services as the residual.

So here we specify consumption of industry goods as function of total consumption. The fit is quite good. The function here is actually

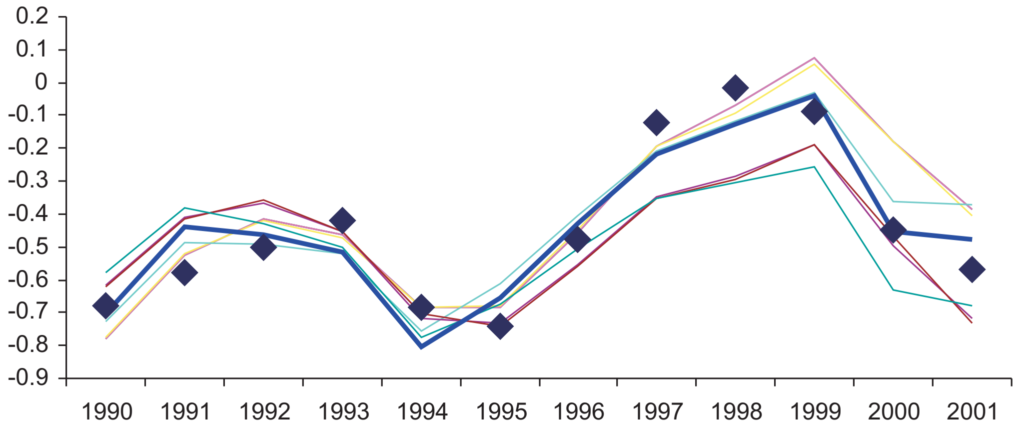
$$C_I = const_1 + (const_2 + \epsilon * P) * C$$

where C_I is the consumption of industrial goods, $const_1$ is the intercept, ϵ is labeled in the table as "elasticity" (not really an elasticity in this case) and P is the ratio of retail price of industrial goods to retail price of food.

9.3.4 Ratio of imports to nontraded goods consumption

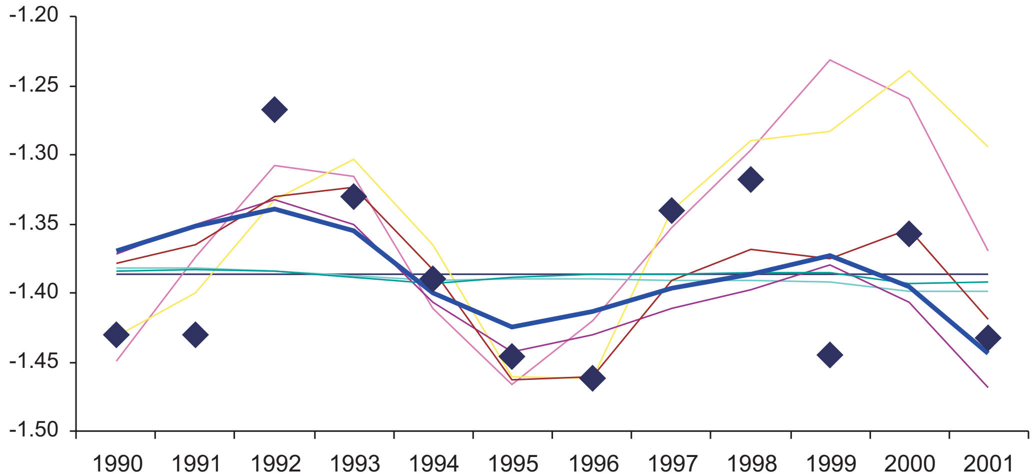
The last relationship we investigate here is the relative price response of import demand. We do it for demand for industrial goods and for services.

(There is no actual data on the split of goods imports into agricultural and industrial, and in the 1993 SAM industrial imports are the majority by far; in compiling the dataset, we have assumed a fixed ratio of industrial to agricultural imports. However, as the agricultural supply constraint made itself felt in the second half of the 1990s, the share of agricultural imports in the total could well have increased - so it would have been cleaner to do this here for goods imports as a whole. On the other hand, the World Bank figures (only available for some years) on the ratio



Industry Imports	Intercept	Time Trend	Elasticity	Time Constant	Estimation R^2	Validation R^2
Constant only	-0.52				0%	0%
Exponential delay	-0.61	0.0075	-1.24	4.49	89%	71%
Fixed delay	-0.62	0.0036	-1.16	3.57	88%	73%
No delay	**-0.63**	**0.0035**	**-1.01**		**79%**	**87%**
Exponential delay, no trend	-0.44		-1.16	3.64	59%	77%
Fixed delay, no trend	-0.44		-1.13	3.87	59%	75%
No delay, no trend	-0.47		-1.01		53%	75%
Best equation estimated on the whole interval	**-0.58 (0.13)**	**0.0027 (0.0014)**	**-1.16 (0.31)**		**88%**	

Table 9.6: *Ratio of imports to nontraded goods in consumed industrial goods as function of relative price*



	Intercept	Time Trend	Elasticity	Time Constant	Estimation R^2	Validation R^2
Constant only	-1.39				0%	0%
Exponential delay	*-1.70*	*0.0022*	*-1.46*	*36*	*76%*	*-434%*
Fixed delay	-1.52	0.0013	-0.53	18.68	80%	-442%
No delay	-1.38	0.0001	-1.01		0%	1%
Exponential delay, no trend	-1.44		-0.60	31.18	37%	-28%
Fixed delay, no trend	**-1.44**		**-0.37**	**18.17**	**58%**	**32%**
No delay, no trend	-1.39		-0.02		0%	0%
Best equation estimated on the whole interval	**-1.44 (0.02)**		**-0.38 (0.11)**	**18.36**	**51%**	

Table 9.7: *Ratio of imports to nontraded in consumed non-government services as function of relative price*

of agricultural to industrial imports suggest that ratio is quite stable. Therefore, we stay with the present formulation for now.)

The predictive power of the constant price elasticity of substitution is quite strong in the case of industry. All variants of the equation that include time trend have a validation R^2 over 70%. The actual elasticity always comes out larger than one, which is good news for trying to control import demand through relative price adjustments.

On a more disturbing note, the ratio of imports to nontraded industrial goods exhibits a disturbing increasing time trend; in itself this is a manifestation of the opening of the economy during the 1990; however, as we have discussed in Chapter 3, imports have consistently outgrown exports. Fortunately, this trend is substantially lower if we estimate the equation for the whole period, indicating a slowdown in endogenous import growth.

The fit was less good for services, with the price elasticity being still consistently negative but varying in absolute value among different functional forms.

Summary

In examining the demand side of the product markets, we have seen that government demand was the major driving force of the economy in the period we examine. Private savings net of investment were actually positive throughout, thus also a net demand drain. The ratio of private disposable income to total private demand (consumption plus investment) was quite stable at about 0.96, possibly implying a savings ratio that adjusts to meet investment demand. Finally, the share of imports vs. domestic goods in consumption demand for manufactured goods in real terms was found to be extremely responsive to their relative price (relative price elasticity of substitution larger than one). This means that the balance of payments will be quite responsive to both the exchange rate and the domestic price level.