LOCAL MANUFACTURING HURT BY DEPRECIATIONS IN A THEORETICAL MODEL REFLECTING THE AUSTRALIAN EXPERIENCE

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Abstract. The model is motivated by data showing that the Australian production of local manufactures is hurt by depreciations and invigorated by appreciations. The paper briefly presents such evidence and then proceeds to a theoretical analysis. The model aims to capture short-to-medium run exchange rate effects in an economy with goods and services aggregated into four commodities: (i) imports; (ii) local manufactures; (iii) services; and (iv) rural goods (agricultural, pastoral, forestry, fishing and mining products). With the exception of rural goods, each commodity comprises consumer goods as well as inputs into the other sectors. Rural goods enter consumption only indirectly after processing by the manufacturing sector. Exports are exclusively rural goods. The model has a Keynesian flavour in that the production of local manufactures and services is not constrained by the availability of resources and of labour. Variable inputs per unit of output are assumed to be constant. There are also fixed inputs. Variable inputs are imports in the case of the import sector; rural goods and imports in the case of the local manufacturing sector; and labour in the case of the services sector. The prices of imports, local manufactures and services are set by constant mark-up factors on variable costs. This assumption is based on a picture of imperfect competition with constant elasticity of demand at the firm level. The extreme capital intensity of rural goods production is taken into account by modelling total production of rural goods as an exogenous parameter. The price of rural goods is determined in the export market. It falls with increasing exports. The economy is not assumed to be small in its export market. The domestic consumption demand schedule is modelled as predetermined in the sense that in the time span under consideration the relationship between quantities consumed and nominal prices is not affected by the exchange rate. The nominal wage rate is assumed to be predetermined in the same sense. No specific functional form is imposed on the consumption demand schedule: the analysis is based on general assumptions, mainly non-inferiority and gross substitutability. In view of gross substitutability, there is a competitive relationship between imports and local manufactures. A depreciation raises the price of imports and ceteris paribus such an increase raises the consumption of manufactures. However, the analysis shows that this enhancing influence of a depreciation on manufacturing is weaker than other causal channels that work in the opposite direction. An increase in the price of imports (and exportables) raises variable costs and thereby the

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price of local manufactures. This leads to a decrease in the output of local manufactures. In the course of the analysis, it is first shown that a uniquely determined equilibrium exists for every exchange rate above a lower bound. Then the effects of a change in the exchange rate are investigated. In most cases the results are unambiguous. In particular this is true for the output and the price of local manufactures. Other conclusions are that a depreciation increases exports and the amount of services provided. In some cases unequivocal results can be obtained only with the help of further assumptions. This concerns the domestic price of rural goods, the balance of trade in domestic prices and import penetration.

1. INTRODUCTION AND EMPIRICAL BACKGROUND

1.1. The phenomenon

When we speak of devaluations and revaluations, besides occasional or frequent (‘crawling’ peg) adjustments of fixed exchange rates, we also think of policy measures influencing exchange rate movements under regimes of floating exchange rates. For even if the value of the home country’s currency is not officially set by a monetary authority in terms of another country’s currency (e.g. in terms of US dollars) but determined in the market, it can be manipulated by central bank intervention.

We shall use the terms devaluation and depreciation interchangeably for deteriorations in the local currency’s buying power regardless of whether the exchange rate change is directly set by the country’s monetary authority, or indirectly set through its monetary authority easing monetary conditions and thereby causing the floating exchange rate to decline in purchasing power. Likewise we shall use the terms revaluation and appreciation interchangeably for improvements in the local currency’s buying power regardless of the exchange rate regime.

Most trade models assume a single traded goods sector (implicitly manufacturing) that both competes on the export market and competes against imports. It seems desirable to also model countries in which the export and import competing traded goods sectors are radically different – in the sort of product made, in the technology used, and in their output and price responses to short and medium run changes in profitability. These include countries in which the local manufacturing sector is primarily import competing in the sense that it produces almost exclusively for its home market and sells very little abroad and exports comprise mainly rural goods – agricultural, forestry, fishing, pastoral and mining products (in the form of raw or lightly processed materials and their concomitant transport to overseas buyers and called rural because they are often produced far from population centres).

Australia is an example of such a country. In the 1970s, the latest period for which such calculations are available, and a period at which we shall look more closely in sections 1.3 and 1.6, less than 4% of local manufacturing value added comprised exports of elaborately transformed raw materials (Australian
Exports of manufactures defined as elaborately transformed raw materials have been growing (Bullock et al., 1993, p. 96; Menzies and Heenan, 1993; Fahrer and Pease, 1994; Menzies, 1994; Mitchell, 1995). Exports of services – health, education, legal and tourism services have also been growing – becoming finally in 1999 absolutely big enough to warrant official estimates. But it remains the case that Australia’s exports are almost entirely rural goods.

The model presented here tries to throw light on how policy measures aimed at an increasing or decreasing the exchange rate influence local manufacturing in such countries. Consider the case of a devaluation of the home currency. Trade models typically suggest that when the relative prices of imported goods compared to local manufactures rise, and that therefore less is imported and more local manufactures are produced (Caves and Jones, 1973; Corden and Neary, 1982; Woodland, 1982; Fischer and Dornbusch, 1983; Dornbusch and Fischer 1984; Neary and Purvis, 1983; Krugman, 1987; Obstfeld and Rogoff, 1997). Thus devaluations are expected to enhance the production of import competing local manufactures, and appreciations are expected to depress it. Models in which devaluations contract total output are no exception. In these models, the nontraded (services) sector contracts more than the traded (manufacturing goods) sector expands after a devaluation (Lizindo and Montiel, 1989; Agénor and Montiel, 1996).

However, in at least one country with an import competing manufacturing sector, Australia, empirical observation seems to contradict this traditional view (Harris, 1963; Pope, 1981, 1985, 1986, 1987; Johns, 1985; Lim and Shannon, 1986; Gaston, 1998). Import penetration tends to be depressed after devaluations but so too does local manufacturing output. When manufacturing eventually does recover, it is in tandem with increased import penetration and at a time when the devaluation-induced relative price changes supposed to favour manufacturing will have been substantially eroded. The response of the manufacturing sector to exchange rate movements is far from obviously corroborating the traditional view and it even suggests that appreciations help manufacturing and devaluations hinder it. This is the phenomenon that motivates our model.

Our model does not, however, include all mechanisms whereby appreciations can help and devaluations hinder local production. In particular it excludes the case modelled in Chen (1974, 1975) of appreciations benefiting local production because the export sector requires rationed foreign currency to buy imports as inputs, and appreciations alleviate this foreign currency constraint.

1 The Australian Treasury defines manufacturing as primarily import competing, agriculture and mining as primarily export orientated, and all other industries as non-traded, Treasury Department (1987). If one classifies as export industries those that export at least 10% of their output, then the following picture emerges. Out of the 109 industries in the 1990–1991 inputoutput tables, only one category of elaborately transformed raw materials is an export industry, the category ‘manufactures not elsewhere included’. Further the only categories of services that classify as export industries are the transport ones associated with Australia’s export trade. See Dwyer and Groeger (1994, pp. 8–9 and appendix 2, pp. 24–27).

2 The Australian Bureau of Statistics released the first such non-transport export series in 1999.
1.2. Plan of the paper

In section 1.3 we look at three time series that illustrate the phenomenon. In section 1.4 we discuss the results of a regression analysis that only loosely relates to our model, but throws further light on the phenomenon. An informal description of the structure of the model is given in section 1.5. Then in section 1.6 we examine the plausibility of this structure as a description of the Australian economy in light of the empirical literature. In section 1.7, the final section of Part 1, we give a qualitative overview of the causal relations and a preview of the results of the model.

A detailed description of the model is given in Part 2. The analysis follows in Part 3. The full system of equations is first reduced to a condensed system and then by section 3.3, to a core system with only three variables: $e$, the exchange rate; $q^*$, the foreign currency equivalent of the price of local manufactures; and $Q$, the total quantity of local manufactures. Some technical questions concerning the existence and differentiability of functions that connect the other variables of the model to the exchange rate are discussed with the help of the core system in sections 3.4 to 3.10. Thereby the further analysis and the derivation of the results in sections 3.11 to 3.31 are put on a solid basis. The paper ends with some short concluding remarks in Part 4 in which we want to draw attention to policy implications.

1.3. Time series for the exchange rate, import penetration and manufacturing

In Australia during 1970–1980, a stated objective of the appreciations was to reduce imported inflation. A stated objective of the devaluations was to expand manufacturing by improving its competitiveness. However, manufacturing output and import penetration tended to rise together about 18 months after the appreciations and to fall together about 18 months after the devaluations. The story is traced in figures 1, 2 and 3.

The exchange rate index used in figures 1 and 3 relates the Australian dollar to a trade-weighted basket of foreign currencies for the period 1970 to 1988. It is defined as the number of Australian dollars needed to buy one unit of this basket. Accordingly a devaluation increases the index and an appreciation decreases it. In order to make it easy to see that the effects of exchange rate

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3 See Kelly (1976, pp. 71–72); Jolley (1978); (Fraser 1985, p. 7); Keating (1985); Stutchbury (1985); and Australia, Parliament (1975, 1981). These latter record Australian parliamentary proceedings, including the fiery parliamentary debates on exchange rate policy in which speakers such as former Prime Minister, Sir William McMahon vehemently denounce appreciations, which they claim have injured Australian manufacturing. They blame the Australian Treasury as a prominent inflation fighter with a key position on the Board of Australia’s central bank. Exchange rate policy has included some devaluations when Australia’s terms of trade have deteriorated, which help the rural sector (Blundell-Wignall et al., 1993; Gregory, 1993; Gruen and Kortian, 1993). However, this exchange rate terms of trade relation is apparent only in the longer run. On a quarterly basis, predicting the Australian exchange rate is as difficult as in other countries, with the current models doing no better than random walks, Pagan (1993).

movements have a lag of 18 months, the time series for the Australian exchange rate is lagged by six quarters in figures 1 and 3.

Figure 1 shows import penetration in the current period and the exchange rate 18 months earlier. The figure reveals that import penetration changes in the opposite direction about 18 months after an exchange rate change. Such a lagged negative relation offers support for the traditional view that appreciations increase imports and import penetration and devaluations reduce it.

Figure 2 shows the time series for import penetration and local manufacturing value added. The traditional view would predict that the devaluation-induced decreases in import penetration would help local manufacturing and the appreciation-induced increases would damage it. However, figure 2 does not reveal such a negative relationship. Quite the reverse – it shows local manufacturing rising and falling simultaneously and in tandem with import penetration.

The time series for the lagged Australian exchange rate and real local manufacturing are shown in figure 3. The three figures suggest that for the Australian manufacturing sector taken as a whole, after about 18 months, each appreciation increased foreign competition as measured by the rise in import penetration and at the same time helped local manufacturing. Conversely, after about 18 months, each devaluation decreased foreign competition as measured by the fall in import penetration, and at the same time damaged local manufacturing.
1.4. A regression throwing light on the phenomenon

1.4.1. Regression results

The picture emerging from figures 1 to 3 is supported by a regression analysis whose results are shown in table 1. The equation is in reduced form since the right-hand side contains only predetermined variables. Further it contains no lagged values of the dependent variable and has no evidence of auto correlation when estimated by ordinary least squares. These features mean that the regression results avoid the interpretation and estimation difficulties of regressions involving either co-integration analysis or simultaneous estimation techniques.

The dependent variable is the logarithm of real value added of Australian manufacturing. The independent variables are either logarithms of lagged economic variables like total Australian expenditure and various price indices or they are dummy variables capturing seasonal factors, policy influences and world market conditions. One of the independent variables is the logarithm of the Australian exchange rate, defined as in figures 1 and 3. The table shows the regression coefficients together with the associated t-values.

The most important result of the regression is the negative sign of the coefficient of the exchange rate index. The lag of the exchange rate index is six quarters. This confirms the impression given in figure 3 that after about

Figure 2. Import penetration and manufacturing value added. The unexpected positive relation: Australia 1970–1988. 1970:1 is the first quarter of the calendar year 1970, 1 January 1970 to 30 March 1970. ... 1988:1 is the first quarter of the calendar year 1988, 1 January 1988 to 30 March 1988
18 months local manufacturing is adversely affected by devaluations and enhanced by appreciations.

The regression analysis uses a concept of manufacturing that is broader than that intended by our model. Lightly processed rural goods that are not normally classified as manufactures were in fact classified as manufactures in the regression analysis, but not in our model. A considerable part of these lightly processed rural goods is exported. A devaluation can be expected to increase the profits and therefore the value added on these exports. It is therefore remarkable that even within this broader concept of manufacturing industries, the regression shows devaluations on average contracting the Australian manufacturing sector, and appreciations expanding it.

The regression analysis was first reported in the PhD dissertation of one of the authors (Pope, 1987). This dissertation also contains two alternative theoretical models of aggregate manufacturing and a third theoretical model disaggregated by stages of manufacturing production. These three models assume that prices are either market clearing prices or else a fixed mark-up on total input costs, that Australia is a small country with respect to exports, and imposes specific functional forms on both the supply and demand schedules. Such specificity enables quantitative conclusions on the size of the change in manufacturing value added following a given exchange rate change. But such specificity robs the conclusions of generality.

The model presented here is quite different from these. It allows for the fact that Australia is big with respect to export markets, assumes that prices are a
### Table 1. Determinants of Z, Australian real manufacturing value added.\(^1\) Ordinary least squares estimates for 1968:2 to 1980:2 of log-log equation

<table>
<thead>
<tr>
<th>Theoretical focus</th>
<th>Minor import price influences</th>
<th>Seasonal factors</th>
<th>Insignificant market conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Constant</strong></td>
<td>Real expenditure(^2) lag 1</td>
<td>Foreign prices(^3) lag 5</td>
<td>Exchange rate(^4) lag 6</td>
</tr>
<tr>
<td>3.00</td>
<td>1.12</td>
<td>−0.55</td>
<td>−0.49</td>
</tr>
<tr>
<td>(1.91)</td>
<td>(10.35)</td>
<td>(5.09)</td>
<td>(4.79)</td>
</tr>
</tbody>
</table>

Numbers in brackets are estimated Student \(t\)-test statistics, \(R^2 = 0.948\), Durbin Watson Statistic (DW) = 2.03.

1. Real Annual Australian Bureau of Statistics Australian value added series interpolated with Australia and New Zealand Bank All Groups Industrial Production series, \(Z\).
3. Overseas wholesale price index, import-weighted basket of foreign indices with import weights up-dated at four yearly intervals, individual country wholesale price data from the Reserve Bank of Australia, import flows from Australian Bureau of Statistics.
4. No. of Australian dollars required to buy one unit of an import-weighted basket of foreign currencies (i.e. index declines as the Australian dollar appreciates, with import weights up-dated at four yearly intervals, individual country exchange rates from the Reserve Bank of Australia, import flows from Australian Bureau of Statistics.
6. \(T_F\) where \(T_F\) is a threshold dummy = 1 when \(F > 1.02\), \(F\) is world manufacturing output relative to trend, United Nations Monthly Bulletin of Statistics series.
7. Dummy for the import quotas imposed from 1975 until after the end of the sample period.
8. June quarter seasonal dummy = 1 in June quarter, = 0 otherwise.
9. September quarter seasonal dummy = 1 in September quarter, = 0 otherwise.
10. December quarter seasonal dummy = 1 in December quarter, = 0 otherwise.
11. \(T_V\) where \(T_V\) is a threshold dummy = 1 when \(V > 1.02\), = 0 otherwise, and \(V\) is Australian nominal gross domestic product relative to trend/Australian M2 money stock, a measure of velocity, Australian Bureau of Statistics nominal gross domestic product series, Reserve Bank of Australia M2 series.
12. Australian Manufacturing Wage Rate/Australian Manufacturing Labour Productivity (\(W/PROD\)), with \(W\) is Australian Average Weekly Earnings inclusive of payroll tax, multiplied by \(ME\) to adjust for the changing ratio of males to females, where \(ME\) is the male equivalent number of Australian manufacturing employees modified to allow for the phasing in of equal pay for females 1969:4 to 1976:3, and \(PROD = Z/ME\), all series constructed from Australian Bureau of Statistics data.
13. Inventory accelerator: rate of change in the previous quarter in Australian Real Gross National Expenditure, \((RGNE_{t-1}/RGNE_{t-2})\).
fixed mark-up on variable costs involved and Leontief production functions place no constraints (beyond being non-zero) on the magnitude of these input–output coefficients, and avoids entirely specific functional forms for demand. Its approach of combining marginal cost pricing, general input–output coefficients on the supply side and nothing more than rather general restrictions on demand, yields qualitative conclusions for manufacturing output regardless of whether the country is big or small in its exports markets. To our knowledge such an approach is not found elsewhere in published work.

The regression analysis was inspired by an earlier theoretical framework and therefore does not directly relate to the new model. Nevertheless it throws light on the phenomena to be explained.

1.4.2. Simplified picture of the regression results

In an attempt to interpret the regression in the context of the model presented here, we restrict our attention to independent variables with $t$-values of at least two. There are eight such variables. Not all of them are essential for a theoretical investigation of the way in which the exchange rate affects local manufacturing output. Two of the eight variables are seasonal dummies. Clearly, a theoretical analysis need not be burdened with the consideration of seasonal factors, even if they are of great importance in practice. Similarly in this paper we shall abstract from the exogenously changing market influences captured by the variable ‘foreign capacity’ (and ‘import quotas’ whose $t$-value approaches two).

The variable ‘foreign prices, lag 1’ has a $t$-value of 4.11, but the regression coefficient is only 0.01. This is very small compared to the coefficient of −0.55 attached to ‘foreign prices, lag 5’. Therefore we also exclude ‘foreign prices, lag 1’ from further consideration, in the same way as we exclude the seasonal dummies and ‘foreign capacity’. Thereby, we arrive at a short list of four independent variables considered relevant to our theoretical question:

1. Real expenditure, lag 1.
2. Foreign prices, lag 5.
4. Output prices, lag 5.

The three price variables in this list have almost the same lag. The lags have been determined statistically as yielding the best fit by testing for individual lags and for sets of distributed lags of up to 14 quarters. The difference between lags 5 and 6 may be due to random disturbances though there are some plausible economic reasons for a somewhat longer lag of the exchange rate over other price influences. In this connection one can think of time needed for the renegotiation of contracts after a change in the exchange rate. In any case without much distortion we can simplify the regression results by making the lags of all price variables equal to the lag 6 of the exchange rate. We choose six rather than five as the common lag, since we are mainly interested in exchange rate effects. Moreover, in figures 1–3 this lag gives the best fit.
The lags in the three price variables in the list are very similar and the absolute values of the regression coefficients of the logarithms of all three price variables (respectively 0.52, 0.55 and 0.49), are also very close together, each roughly equal to 0.5. The differences between these coefficients may also be due to random disturbances. We therefore further simplify the regression results by changing all three of them to 0.5. In order to describe the result of these simplifications, we introduce the following notation:

- \( Z \), real local manufacturing value added, current period;
- \( E \), real total expenditure, lag 1;
- \( e \), exchange rate import-weighted average of foreign indices, lag 6;
- \( p^* \), foreign prices import-weighted average of foreign indices, lag 6;
- \( q \), local manufacturing output prices in Australian dollars, lag 6;
- \( \mu \), factor capturing various exogenous influences.

Our simplified version of the regression results can now be expressed as follows:

\[
Z = \mu E^{1.12} \left( \frac{q}{e} \right)^{0.5}
\]

In view of the presence of fixed costs, changes in gross operating surplus are likely to be positively correlated to changes in total local manufacturing output. In turn this means that \( Z \), the value added component of local manufactures – namely gross operating surplus plus labour – is also probably closely positively correlated to total local manufacturing output \( Q \), the quantity variable for Australian manufacturing in our model.

It is plausible to look at real total expenditure \( E \) as capturing short run demand influences, some of which have exogenous causes. The factor \( \mu \) is not supposed to capture all exogenous influences, only those that change the relationship between the variables modelled explicitly. Although we model foreign prices \( p^* \) explicitly they will be considered an exogenous parameter for the purposes of this analysis. The equation is rearranged below to separate off into a square bracket the factors treated in our model as exogenous parameters from our model’s key variables:

\[
Z = \mu E^{1.12} \left( \frac{q}{p^*} \right)^{0.5}
\]

The two terms in the round bracket state that local manufacturing output \( Z \) depends on the exchange rate \( e \), the exogenous causal variable in our model, and on the price of local manufacturing output \( q \). This price is both a proximate cause of changes in local manufacturing output \( Z \), as well as being itself an effect of changes in the exchange rate \( e \).

It is a general equilibrium model.

It is not, however, neoclassical. It differs in three respects: (i) its Keynesian flavour in having unconstrained output in the import, local manufacturing and local services sectors; (ii) its lags in responses; (iii) its pricing assumptions.
These deviations from the neoclassical version of general equilibrium have been made on the basis of empirical evidence.

In justifying our model we refrain from the usual practice of deriving demand from a representative consumer maximisation of expected utility over some time horizon for two reasons. First there is solid empirical evidence that consumers do not maximise. Second, it was proved in the early 1970s that such maximisation derivations are empirically empty once there is more than one consumer (even in some circumstances if all consumers are identical), and thus place no restrictions on demand whatsoever (Sonnenschein, 1973; Andreu, 1983; Chiappori and Ekeland, 1996). It seems undesirable to waste journal space on empirically empty derivations. It has been suggested to us that such derivations are needed to signal competence. We prefer to signal our competence in something relevant to the issue being explored, something largely neglected in the trade literature, namely proving that the equilibrium really exists and is unique.

Our model is designed to capture the impact on local manufacturing output about 18 months after an exchange rate change. It is static in the sense that it does not model the intervening lags and responses whereby after about 18 months the change in the exchange rate has, through changes in the price of local manufactures and other relevant prices, caused this change in local manufacturing output. Within the context of our model, the likely reasons for such an overall lag are as follows. Prices are formed by mark-ups on unit variable costs. The underlying picture is that of firms acting in markets with imperfect competition, though the competitive interaction of firms is not explicitly modelled. In such markets there are several factors that may cause delays in output responses to price changes. Mark-ups may be based on historic costs prevailing when inputs were ordered. This would involve a lag between order date, their receipt (often from overseas), and their use in production. The process of production again takes some time, and finally there may be a lag between the completion of production and when the product is sold. Price rigidities connected to kinky demand curve behaviour and to long-term relationships between buyers and sellers may be further reasons why prices only slowly adjust to cost changes. Thus it may well be that local manufacturing prices change only about two quarters after the exchange rate. There may then be a further lag of about four quarters before quantity demanded responds to the price change causing a change in local manufacturing output. This yields an 18 month lag between the exchange rate change and the change in local manufacturing output.

The regression results show that \textit{ceteris paribus} a change in the exchange rate by a small percentage leads to an opposite change in real local manufacturing output by roughly half this percentage about 18 months later. Thus in the equation for local manufacturing output $Z$, an increase in the exchange rate $e$ that is a devaluation, \textit{ceteris paribus}, decreases local manufacturing output by half this percentage. However, other things will not be equal. The increase in the exchange rate $e$ also increases the price of local manufactures $q$ since in our model this price is set by input costs and input costs will go up after a
The effect of a devaluation on local manufacturing output \( Z \) therefore depends on both the change in \( e \) and also the resultant change in \( q \). The regression results and the round bracket term in the equation for \( Z \) tells us more than this. They show that what matters is the effect of the exchange rate on the ratio of \( q \) to \( e \). Local manufacturing output contracts after a devaluation if the proportional increase in the price of local manufactures \( q \) is less than the proportional increase in \( e \).

To form an intuition of why this might be, consider the following. After a devaluation costs of exports and imports rise. This upward shift of supply will increase the price of local manufactures less than proportionately, provided that demand is downward sloping. If this were all that happens, then unambiguously the price of local manufactures \( q \) increases less than proportionately with the increase in the exchange rate \( e \), and devaluations contract local manufacturing. However, this is not all that happens. Imports comprise not only inputs into local manufacturing. They comprise also goods competing with local manufacturing. Since these competing goods become more expensive after a devaluation, this shifts upward the demand for local manufacturing output. If this upward shift in demand is big enough and the supply-demand curves are sufficiently price responsive, the price of local manufactures \( q \) will increase more than proportionately with the consequence that devaluations contract local manufacturing as in standard trade models.

Thus the net effect of a devaluation on local manufacturing output is expansionary if it shifts the demand curve up sufficiently modestly relative to the upward shift of the supply curve. It would seem implausible without either standard trade model constraints or the specific demand functions of the theoretical models in Pope, 1987, that a theoretical model can determine this net effect. Nevertheless, despite imposing no specific functional form on the consumption demand schedule apart from very general assumptions, mainly non-inferiority and gross substitutability, this model yields the definite conclusion that an increase in the exchange rate – in other words a devaluation – increases the price of local manufacturing \( q \) less than proportionately and thereby decreases total local manufacturing output \( Q \).

The regression analysis is not very well suited to a comparison with the model to be presented here since it was derived under Cobb-Douglas supply and demand with market clearing prices. Nevertheless it provides evidence of the phenomenon to be explained by our model.

1.5. Structure of the model

The formal presentation of the model is in Part 2. In this section we offer an informal introduction to the structure of the model. The plausibility of this structure as a description of the Australian economy is examined in section 1.6. Section 1.7 presents an overview of the causal relations and a preview of the results of the analysis.

The model aims at the short-to-medium run. Therefore it does not try to cover repercussions of the exchange rate that only take place later, in the
medium-to-long run. Presumably after all these later repercussions have occurred, relative price effects will have been whittled away very substantially so that by this later time the principal remaining impact of the exchange rate is on the general price level, not on the real sector.

1.5.1. Sectors
The model describes an open economy with goods and services aggregated into four commodities:

1. Rural goods: (output of the agricultural, pastoral, forestry, fishing and mining industries).
2. Imports.
3. Local manufactures.
4. Services.

Only the latter three are directly consumed. Rural goods enter consumption only indirectly after processing by the manufacturing sector. If we speak of a sector we mean all economic activities connected to the supply of the relevant aggregated commodity, from the acquisition of its inputs to the disposition of its final outputs either to overseas buyers, or to other sectors needing them as inputs, or to local consumers.

Because our model includes all tiers in a sector’s production chain up to the goods being exported, used as inputs into another domestic sector, or consumed locally, we need a somewhat different division of industries between the rural and local manufacturing sectors than is normal. This concerns lightly processed materials. We count them as rural goods if they are exported or used as inputs into other industries. However, those lightly processed materials that are locally consumed are counted as local manufactures. We do this because in our model the retailing of manufactures is looked upon as part of the manufacturing sector, and retailing contributes a substantial part – about half in the case of Australia (Pope, 1987, table 6.3) – of the value added of lightly processed materials.

We think of the service sector as including only service industries like the restaurant and hotel business whose sales are significantly dependent on short-to-medium run consumer decisions. This excludes public goods like defence, education and health services whose scale of operations is largely dependent on political decisions rather than on market forces. It seems to us that long-term consumption investment including housing also needs to be excluded since it depends on consumer decisions that transcend the short-to-medium run. We may say that our model only looks at those parts of total expenditure determined by short-to-medium run consumption decisions. Decisions on investments and publicly produced goods transcend the time scope of our framework.

1.5.2. Exogenous production quantities of rural goods
The industries that produce what we call rural goods may seem to be strangely heterogeneous, but they are thought of as sharing two features that justify
putting them into the same sector for the purposes of our model. First, the only exports are rural goods. Second, in these industries production seems to be largely determined by capacity limits, rates of technological progress and random factors like the weather in the case of agriculture. We accordingly treat the total production of rural goods as an exogenous parameter that does not respond to changes in input and output prices. Of course, in the long run, through changes in the number of matured trees, animals, dams and fences, boats and mines – capacities may respond to input and output prices. But our model aims at the short-to-medium run only.

1.5.3. Unconstrained production of local manufacturing and services
As far as local manufacturing and services are concerned, the model has a Keynesian flavour. We look at a situation with not fully used capacities in these industries, involuntary unemployment of labour and expandable supplies of materials by changing the quantities of these exported and imported. Accordingly within the model’s short-to-medium run perspective the production of local manufactures and the supply of services are not constrained by either capacity limits or the scope to increase variable inputs.

1.5.4. Fixed and variable inputs
Variable inputs per unit of output are taken to be constant. There are also fixed inputs in each sector. Variable inputs are imported goods in the import sector, rural goods and imports in the local manufacturing sector. Variable inputs are labour in the services sector. Since in the rural sector total production is exogenously determined, it does no harm to treat all their inputs as similarly exogenously fixed. Accordingly there are no variable inputs in the rural sector.

Within the short-to-medium run time span of our model, labour inputs in the import and manufacturing sectors are exogenously fixed. Only material inputs are treated as variable in these two sectors. By contrast, labour is the only variable input in the services sector.

Modelling labour inputs in the import and local manufacturing sectors as fixed is based on the idea that in the production and distribution of physical goods much of the labour input varies with capacity rather than output and that for institutional and technological reasons even those labour inputs that depend on output cannot be easily adjusted in the short run. However, in the service sector the situation is different. The ability of a firm to meet peaks in demand depends heavily on labour inputs. There also seems to be more flexibility in employment than in the manufacturing sector.

Of course, our characterisations of variable inputs into each sector are simplifications that may not be fully justified. They could be relaxed to some extent, but this would unduly complicate the analysis and make the theoretical conclusions less transparent. In our model, prices are formed by constant mark-ups on unit variable costs. In this connection it should be pointed out that what we have termed variable costs has an alternative interpretation: they
are not the entire set of output-dependent costs, only those ‘calculatory’ variable costs on which price calculations are based.

1.5.5. Price of goods in local and foreign currency
Our model describes a country that is not small in its export markets. Rather it has some influence on the world market prices for its exports. Therefore the border price of rural goods in foreign currency is determined by an export demand schedule in which its unit price is a decreasing function of the total quantity of exports. The price of rural goods in local currency to local users is the border price of those exports in foreign currency times the exchange rate. By contrast our model describes a country that is small in its import market. The landed price of imports in local currency is their world market price times the exchange rate.

Note that in our model it is necessary to distinguish between three import prices in local currency, the landed price $p_0$ paid by importers; a wholesale price $p_1$ at which they sell to retailers and manufacturing firms; and finally $p$, a retail price paid by consumers. Similar distinctions do not have to be made for the other sectors. As far as manufacturing and consumer services are concerned, we can restrict our attention to retail prices. In the rural sector, the wholesale price is the only one in local currency. Therefore when we refer to prices outside the import sector, we shall often simply speak of the price of manufacturing, or the price of services or the price of rural goods.

1.5.6. Constant mark-up factors
We assume that the wholesale price of imports and the retail prices of imports, local manufactures and services are set by applying constant mark-up factors to unit variable costs. This feature of the model is based on the idea that firms interact on markets with imperfect competition. Perfect competition would not be viable in an environment with fixed costs and constant unit variable costs. Suppose that in a market with price variation all competitors face the same constant elasticity firm demand function and that all of them have the same linear cost function. It is well known that under this condition profit maximising prices are achieved with a fixed mark-up factor applied to variable costs per unit. (Models of imperfect competition and international trade have been based on this in other reports, e.g. Helpman and Krugman, 1985). Our fixed mark-ups may also be thought of as describing a behavioural rule that is not necessarily optimising. This is suggested by the empirical literature on the behavioural theory of the firm (Cyert and March, 1963).

1.5.7. Exogenous wage rate
In our model, the wage rate is not influenced by an exchange rate shift within the time span under consideration. The nominal wage rate is predetermined. Since labour is the only variable input into services, this has the consequence that the price of services is not influenced by the exchange rate, and is likewise predetermined.

1.5.8. Demand

We do not have constant elasticities of total demand. Firm demand functions may look quite different from total demand functions. The former may have constant elasticities while the latter do not. However, we shall not explicitly model competition at the micro level.

The model abstracts from non-consumption demand (public sector expenditure and private investment). It does not link changes in domestic expenditure to changes in income-asset constraints occasioned by the exchange rate change. Within the short-to-medium run perspective of our model, if after an exchange rate change, the changes in planned domestic expenditure do not equal the changes in the country’s income, it is the country’s level of overseas borrowing – not its domestic demand schedule – that adjusts.

The domestic demand schedule itself is modelled as predetermined in the sense that in the short-to-medium run time span under consideration, the relationship between quantities consumed and nominal prices is not affected by the exchange rate. No specific functional form is imposed on the consumption demand schedule.

In our model a change in the exchange rate influences the demand for services. Thereby eventually the demand for labour in the service sector will change. However, we assume that employment in the service sector will respond to this with a considerable delay because it takes time before firms discover the change in demand that is hidden by the usual random fluctuations.

Manufacturing is likewise exposed to random fluctuations in demand. But in this sector firms have inventories of materials and finished goods. Production varies almost in tandem with these random fluctuations as output is adjusted to a desired level of these stocks. In the services, by contrast, there is no scope for storing stocks of finished goods so that increasing the variable input labour in response to short-lived random fluctuations in demand is entirely wasted. In addition the costs of changing the quantity of labour employed are high relative to the costs of changing material inputs quantities. These two factors combine to cause the service sector to wait until it is reasonably confident that the demand change is permanent before altering quantities, and thereby to respond much more slowly than the manufacturing sector to fluctuations in demand.

The analysis is based on some general assumptions concerning the domestic demand schedule. The most important ones are gross substitutability and non-inferiority. Gross substitutability means that the cross price elasticities are positive: increases in the price of any one consumption good leads to increases in the quantities demanded of each of the other two consumption goods. The term non-inferiority is used in the sense that an equal percentage increase in the prices of all three consumption goods decreases the quantities demanded of all three consumption goods, imports, local manufactures and services.

The predeterminedness assumptions abstract from exogenous influences on consumption demand and on the wage rate. Such influences must be expected to be present in reality.

1.6. The model structure and the Australian economy

In this section we examine the plausibility of the model structure as an idealised description of the Australian economy.

1.6.1. Sectors

The model’s division of unprocessed and lightly processed goods between the rural and manufacturing sectors is on the basis of consumption. Virtually none of Australia’s output of unprocessed raw materials is directly consumed. The model therefore classifies these industries as entirely rural. Australian rural goods that are lightly processed are food, textiles, coal and petroleum products, and basic metals. The proportions of these four lightly processed materials directly consumed locally, range from roughly 50% in the case of food products, to zero in the case of basic metals. In each case almost all the remainder that is not used as an input to itself is exported. Our division of these lightly processed products between the rural and local manufacturing sectors thus leads to a 50/50 split of the food processing industry between the rural and manufacturing sectors, and to the basic metals industry being classified as entirely rural.

1.6.2. Exogenous production quantities of rural goods

The model treats quantities of rural goods as exogenously determined and comprising all goods exported. Australia’s exports together with their transport to overseas markets are almost exclusively goods defined in our model as rural. For their production in Australia, land and mining capacity are binding resource constraints even beyond the short-to-medium term perspective of our model. Marginal costs are very low. Even substantial decreases in the price of rural output do not provide an incentive to cut production because they do not lead to prices below marginal cost.

1.6.3. Unconstrained production of local manufacturing and services

The model’s Keynesian flavour for the manufacturing and services sectors would be inappropriate at the height of a major cyclical boom. In regard to capacity, Australia has not seemed to have enjoyed buoyant conditions at capacity limits since the early 1970s. In regard to access to variable inputs, consider first the manufacturing sector. As discussed in sections 1.6.4 and 1.6.6, the variable inputs for manufacturing are largely materials in the form of: (i) rural goods; and (ii) imports.

Imports constitute about 50% of manufacturing materials costs, and rural goods make up almost all the remainder (Pope, 1987, table 4.9). In the case of the manufacturing sector’s access to rural materials, the issue is whether, given rural output fluctuations related to the weather and strikes, after fixed long-term rural export contracts are met, sufficient rural output remains to meet the input needs of the manufacturing sector. In 1974–1975 the proportion of rural sector production used by Australian manufacturing was only 19% (Pope, 1987, table 4.4; Australian Bureau of Statistics, table 11). This perhaps explains why, to our knowledge, shortages of rural inputs are not a policy issue raised in...
discussions on Australian manufacturing welfare. In periods of Australian manufacturing expansion, there would seem to be a sufficient level of Australian rural output for Australia’s manufacturers to increase their purchases at prices slightly higher than world (spot) prices in Australian currency to entice the rural producers not to export these quantities. It seems reasonable to look on the quantity of rural goods sold on the export (spot) market as a residual after both long-term export contracts and Australian manufacturing requirements have been met.

In the case of the other main variable input into manufacturing, imported goods, after World War II, many countries including Australia and Taiwan suffered from bottlenecks and delays in obtaining sufficient imports at times of domestically imposed import quotas or high world demand. There is theoretical and econometric evidence that such import constraints can hamper domestic output, and in the case of Australia, manufacturing output.\(^4\) But import shortages have been modest in Australia since the early 1970s.

In short, it seems reasonable to characterise Australian manufacturing as unconstrained by either the availability of rural goods or of imports, its two main variable inputs.

In the Australian service sector, as discussed in section 1.6.5, the prime variable input is labour, much of it unskilled. Since 1970, and especially since the worldwide recession in the first quarter of 1974, Australia has had a surfeit of unskilled labour. Thus the model’s Keynesian feature that employed labour in the service sector can be increased in the short-to-medium term also seems reasonable.

1.6.4. \textit{Labour input rigidities in the import and manufacturing sectors}

Within the short-to-medium time frame of our model, technical progress is excluded. This is compatible with the model structure of some fixed inputs in all sectors and constant variable inputs per unit of output in those sectors that do have variable costs within this intermediate time frame.

The model characterises the import sector as having its major cost, landed imports, as its only variable cost, and similarly characterises the manufacturing sector as having its major cost, materials, as its only variable cost.\(^5\) The other three broad cost categories for these two sectors, labour, tertiary services and capital, are difficult to vary significantly in the short-to-medium run. In the case of capital this may seem self evident. But it is likewise difficult for the import and Australian manufacturing industries to vary labour inputs within the short-to-medium run, whether by hours per worker or by numbers hired.

Variation in the hours worked by hired workers is difficult. Workers typically have a normal amount of overtime built into their contracts implicitly

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\(^5\) On the cost structures of these industries, see Pope (1987, table 4.8, p. 236 and columns 166–171 of table A4.3.1, p. 264).
or explicitly, limiting the scope to increase their hours further. When reductions in hours have been sought, even where this merely means reducing overtime, labour strikes and disputes occur (e.g. Anonymous, 1998 in the Canberra Times report of the Australian Council of Trade Unions (ACTU) negotiations on ‘the right to overtime’). This is because overtime is paid at higher penalty wage rates, and is subject to agreed-upon annual norms.

Variation in the number of hired workers is also difficult. Short-to-medium run increases in numbers of workers hired are difficult due to the costs of hiring and training skilled workers (especially because Australia’s limited skills pool frequently requires overseas recruitment and immigration procedures). The short-to-medium run costs of reducing the numbers of workers can be prohibitive – the risk of expensive labour protest from involuntary dismissals and the cost of ‘golden handshakes’ required to achieve the alternative, voluntary quits. It seems more reasonable therefore to view both labour and capital as fixed within the short-to-medium run time frame of our model.

It may be similarly difficult to vary in the short-to-medium run the other cost category into the imports and Australian manufacturing sector, tertiary inputs. These comprise things like repairs, wholesale and retail inputs, insurance, finance, public administration and defence charges.

1.6.5. Labour flexibility in the service sector

Our characterization of the service sector as having labour as its only variable cost may be approximately true for Australia. In contrast to the primarily full-time workers in the import and manufacturing sectors, the service sector’s labour force comprises a large proportion of temporary and part-time workers with high turnover rates and limited or no job tenure. This makes short-to-medium run variations in its workforce viable. This sector’s use of materials input is modest (Pope, 1987, table 4.8, p. 236), and its other principal cost, capital, is difficult to vary in the short run.

1.6.6. Input-output evidence on materials as the only variable input into imports and manufacturing

Under the assumption of fixed mark-ups on unit variable costs, we can find empirical evidence for materials being the only variable input into imports and manufacturing. In order to examine these questions for Australian manufacturing, one needs data on input and output prices. In addition one needs data on input and output quantities derivable, after extensive manipulations, from input–output tables. Unfortunately, Australian input–output tables are only infrequently constructed. However, the consecutive Australian Bureau of Statistics input–output tables of 1968–1969 and 1974–1975 can be used for our purposes, despite the fact that the 6 year time lapse between these dates is much longer than our model’s short-to-medium run perspective of six quarters. It happens that Australia had comparatively little change in prices and wages between 1968–1969 and about 1973, followed by a rapid increase in prices and wages (e.g. Foster, 1996, tables 1.13 and 4.17). The consequence is that between 1968–1969 and 1974–1975, almost all the relative price/wage changes occurred
in the last six quarters of this 6 year time span. In turn this means the assumed fixity of mark-ups on unit variable costs in these sectors between 1968–1969 and 1974–1975 does shed light on their short-to-medium run variable costs.

Between 1968–1969 and 1974–1975 the wholesale and retail mark-ups over the landed price of imports remained approximately constant. During the last six quarters of this period, the landed prices of imports rose by about 50%, as did their prices to final Australian buyers (Pope, 1987, columns 166–171 of table A4.3.1; Foster, 1996, table 1.13). Such a constant mark-up would occur if the only variable cost entering the mark-up basis in bringing imports to the consumers is that of the imported goods themselves.

Likewise during this same 6 year period from 1968–1969 to 1974–1975, with respect to the Australian manufactured consumer goods price, the combined wholesale–retail mark-up on imported and rural inputs into Australian manufacturing remained approximately constant. During the last six quarters of this period, the price of Australian manufactured consumer goods rose by approximately 50%, as did the prices of the imported and rural inputs used in their production (Pope, 1987, tables A4:2.1, A4:2.2, 4.3, 4.4, 4.16, 4.17 and 6.3; Foster, 1996, table 1.13; Australian Bureau of Statistics, Home Produced Materials Price Index, unpublished data, supplied in 1985). During this same 6 year period from 1968–1969 to 1974–1975 wage rates doubled, a period when labour rose to about 36% of costs in Australian manufacturing to the ex-factory stage, and to about 41% of the wholesaling and retailing costs of bringing Australian manufactures from the factory gate to final buyers. While in retailing and wholesaling productivity increases could absorb this wage rate rise, there were not comparable productivity increases in the factory stage of Australian manufacturing (Pope, 1987, tables A8:1.3 and A8:5.1, pp. 567–568, 584). Therefore, if labour had been deemed part of the variable costs basis to which a fixed mark-up is applied in the short-to-medium run, one of two things should have happened. To reflect the rise in the mark-up basis, the price of Australian manufactured consumer goods should have risen by more than it actually did – by some 20 percentage points more. Alternatively, to bring the manufacturing labour productivity rate into line with the doubled wage rate, there should have been dramatic labour shedding within the short-to-medium run time span of six quarters. The fact that neither of these things happened suggests that labour is viewed by Australian manufacturing as a largely fixed cost in the short-to-medium run.

1.6.7. Econometric evidence on variable inputs into manufacturing

Further supportive evidence for assuming materials are the only variable cost for Australian manufacturing in the short-to-medium term perspective of our study is to be found in econometric manufacturing pricing studies. Gregory

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6 For only one minor category, stocks, was there any change in the margin at all.

7 In addition the mark-ups on Australian manufactured inputs supplied to other sectors also remained approximately constant. However, their constancy does not affect the model's conclusions since these inputs are themselves assumed to be fixed (Pope 1987, columns 151–156 of table A4.3.1, p. 263).

(1978) is a study of the relative price determinants for different industries within Australian manufacturing 1970–1971 to 1974–1975. For the explanator materials, the point estimate is more than double, and its estimated Student’s $t$-test statistic more than four times bigger, than that of his labour cost explanator. Further, Gregory pooled time series and cross-sectional data. Relative materials costs were volatile over time because of the very different price time paths of the different materials used by different industries. Relative labour costs were more or less constant over time because of Australia’s centralised wage fixing but highly variable between individual manufacturing industries. In turn this means that the cost of materials was the only variable item in the short-to-medium run perspective of our model. (Indeed even in the longer run, there would have been only modest time-wise variability in relative labour costs). The role of the differential labour costs between industries, it seems reasonable to conclude, is to vary the size of the fixed industry mark-ups on variable costs between industries. Those with higher labour (and capital) costs would have bigger fixed mark-ups.

Econometric evidence that materials were the only short-to-medium run variable cost for manufacturing can also be found from an analysis of O’Reagan and Wilkinson (1997). This study investigates the pricing of ‘importables’, a category that roughly corresponds to Australian manufacturing, over the period and sub-periods of 1977–1995. It gives estimates of the speed of adjustment to long-run price elasticities in response to import price changes (O’Reagan and Wilkinson, 1997, table 3, p. 21). According to these estimates, in the short-to-medium run, (i.e. after six quarters, the price of local manufactures will have risen by about half the rise in the price of imports). This 50 percent rise is roughly the import share of manufacturing material costs (Pope, 1987, table 4.9, p. 236). In their econometric regression, they omit any other explanators of Australian manufacturing prices. One omitted explanator, according to our view, is the price of rural inputs. Due to the volatility of commodities prices, including the price of rural goods produced in Australia, during the periods covered by published and unpublished Australian Bureau of Statistics data, the price of rural inputs into manufacturing was largely uncorrelated to the price of imports. Accordingly their omission of the price of rural goods should not have biased the estimates significantly. The other possible omission from their estimating equation is the wage rate. During this period and each of the sub-periods for which they made econometric estimates, wage rates rose at roughly the same rate per annum as import prices. Therefore, if the price of manufactures were formed as fixed mark-up on variable costs, and variable costs included labour, import prices would be a proxy for the combined impact of both the labour and imported input cost components. In the O’Reagan and Wilkinson (1997) regression the dependent variable, the price of Australian manufactures, is in first difference levels. Hence if the price of Australian manufactures were formed as fixed mark-up on variable costs inclusive of labour, the estimated speed of adjustment coefficient and the long run price elasticity response to import prices would both be upward biased. The upward bias should have resulted in the price of Australian manufactures being
estimated, on average, as having risen after six quarters by about 85% of the increase in import prices (i.e. by the increase in import prices plus the increase in wages). The fact that they did not obtain such estimates, but rather much lower ones of just over 50 percent of the price rise in imports, is therefore additional corroborating evidence that materials are the only variable cost entering the mark-up basis used in the pricing of Australian manufactures.

1.6.8. Influence on export markets and exchange rate pass-through

Our characterisation of the country as big in the world market for its rural exports is appropriate for Australia. Producing over a third of the world’s merino wool, Australia has considerable influence on this world wool market price. In exports of other rural products, Australia supplies between about one-fifth and one-tenth of total world output. This is a big enough contribution to affect world prices (Gordon, 1986; Menon, 1996; Powell and Murphy, 1997, pp. 203–205; Swift, 1998, pp. 169–170). Setting the price of rural goods in local currency to local users to be the same as the border price Australian exporters receive in foreign currency on the world market times the exchange rate is likely to reflect the Australian situation in light of the fairly undifferentiated nature of the rural goods.

The parallel feature of the model, namely that the landed price of imports reflecting 100% exchange rate pass-through, is a feature that requires explanation. In most countries, including Australia, the imports endogenous in our model, namely materials and consumer goods, are primarily differentiated products. In the very short run, meaning lags of only one to two quarters, our assumption of 100% exchange rate pass-through for such differentiated products does not hold. In this immediate future, Australia is apparently a sufficiently important market for the individual overseas suppliers for some market power to be practised (Australia, Parliament 1973, 1974). But it seems that by about a six quarter lag, the short-to-medium run comparative statistics perspective of our model, Australia is sufficiently small for this to be approximately true. Where the exchange rate change is adverse to the overseas buyer (devaluations of the Australian dollar), with this time lag, they seem to find alternative markets to Australia rather than continuing to take a cut in mark-up price. Conversely for the Australian importers when they are not receiving a reasonably complete pass-through of cost cuts in the case of appreciations, within six quarters they appear to have found alternative overseas suppliers. Thus for instance in Dwyer et al. (1994, figure 2, p. 413) the estimate is that although there is limited pass-through in the first two quarters after an exchange rate change, 95% of the exchange rate change has been passed through into the Australian landed price of imports within four quarters. In a similar vein, the Australian Bureau of Statistics has conducted surveys among importers and reached the conclusion of virtually 100% pass-through in three quarters at the landed, wholesale and retail stages (unpublished data, supplied in 1985). However, we lack a long enough time series on retail import prices for unambiguous corroborative econometric work on the retail pass-through (Dwyer and Lam, 1994, pp. 31–32).
1.6.9. Fixed mark-ups independently of prices of competing product and excess demand

For Australia there is a good deal of empirical support for the model’s feature that manufacturing prices are indeed primarily on a unit variable cost plus basis. In particular, despite manufactures being thought of as importables, it is difficult to detect a significant sizable influence of competing imports and excess demand. Thus in Gregory’s (1978) study cited in section 1.6.7, a zero coefficient of determination is obtained when limiting the manufacturing price explanators to that of competing imports. He found statistically insignificant regression coefficients for the price of competing imports and for local demand conditions when these explanators were included in conjunction with costs. For costs alone as the explanators, he obtained a coefficient of determination of 0.94. By incorporating industry-distinctive import competing and excess demand measures or for asymmetries in increases and decreases in competitive pressures, it is feasible to discern competitive effects on Australian manufacturing prices (Haig and Wood, 1976, 1977, 1978; Hall, 1977, 1980; Saunders, 1980, 1981; Hall and Saunders, 1984; Bloch, 1992; Bloch and Olive, 1996, 1998). However, these demand effects are generally statistically insignificant and absolutely very small. Empirical pricing studies suggest therefore that Australian manufacturing prices are reasonably approximated by our assumption of fixed mark-ups on unit variable costs.

In the import sector, the model’s feature of fixed mark-ups on unit variable costs is corroborated by the evidence on fixed mark-ups at each stage discussed in sections 1.6.8 and 1.6.9. In the service sector, we are unable to corroborate the model’s feature of fixed mark-up pricing due to the lack of unit pricing data.

1.6.10. Demand

In Australia private and public sector borrowing overseas is the buffer between income and expenditure plans. Thus a predetermined consumption demand function that abstracts from any short-to-medium effects of the exchange rate on the relationship between quantities consumed and nominal prices, as in our model, is feasible. In addition it seems likely to reflect the actual Australian function. To see this it is desirable to analyse separately Australian rural and urban consumption. Consider first the rural sector. In Australia this is the capital intensive export sector and therefore a local sector with the big gains and losses in nominal income in the short-to-medium run after an exchange rate change. Yet its consumption response in the short-to-medium run is likely to be close to zero. Almost all the evidence points to a country’s rural sector having an extremely low marginal propensity to spend out of income compared to the urban sector. It was the US farmers’ lower average and marginal propensities to consume out of disposable income compared to non-farm families, that led Australian Arthur Smithies (1945, p. 6) to conjecture that the upward drift of

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8 Friedman’s permanent income hypothesis can be used to predict this, Friedman (1957, pp. 40–69) as can the partial adjustment, life cycle and relative income hypotheses.

the US consumption function was connected with the urban population drift. His conjecture is abundantly borne out in the case of Australia.  

Consider now consumption responses in the Australian urban sector after an exchange rate change. It experiences the change in input costs of imports and Australian manufactures passed on with a gestation lag to its final consumers. But after these prices have changed, there is then a further lag before wages react to these cost of living and demand pressures. Then after Australian consumers’ nominal incomes change, there is yet another lag before consumers alter their nominal price responses to these exchange rate induced price changes (Evans and Higgins, 1972; Johnston and Looker, 1979). This makes it implausible that within the short-to-medium term time perspective of our model, consumers would significantly change their set of responses to nominal price changes. Hence the predetermined character of our demand function seems reasonable.

Our model’s demand feature of gross substitution between consumer imports and locally manufactured consumer goods is econometrically corroborated (e.g. Alaouze, 1977; Alaouze et al., 1977; Brain et al., 1979; Bullock et al., 1993, tables 6–8, figure 9, pp. 102–105; Dwyer et al., 1994, tables 3, A3). It is difficult to check on the model’s demand features of gross substitutability between consumer imports with consumer services and between locally manufactured consumer goods and consumer services in view of the difficulty of getting a consumer services price index. Services directly consumed are primarily those of the repair, entertainment, club, hotel, restaurants and personal services industries. The lack of Australian price indices for most of these consumer services means that we also lack data on the model’s non-inferiority feature. Hildenbrand (1998) points out that at a more disaggregate commodity class level, this noninferiority assumption is supported by the empirical investigation of British consumption in Blundell et al. (1993, table 3, section C, p. 581).  

1.7. The causal diagram and preview of the results

1.7.1. Graphical conventions
The causal diagram shown in figure 4 provides qualitative insight into the causal relationships implied by our model. The boxes represent variables in the system. The arrows at the links point from the influencing variable to the influenced one. A link between two boxes symbolises a \textit{ceteris paribus} direct impact of the influencing variable. Therefore, the influencing variable’s \textit{ceteris paribus} direct impact is what its impact would be if it were the only variable

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9 Girao et al. (1974), show that all these hypotheses fit their consumption data for United States southern Minnesotan farmers reasonably well, and that for each hypothesis the short and long run marginal propensity to consume of farmers was low, and lower still for the group of southern Minnesotan farmers whose income was less stable than that of other southern Minnesotan farmers. For the Australian evidence (Arndt and Cameron, 1957, p. 109; Duloy and Nevile, 1965; Smyth and McMahon, 1972, p. 231; Rutledge and Madden, 1974; Mullen et al., 1980, 1985; O’Mara, 1985a, 1985b).

10 Blundell’s tables include a category called ‘services’, but we were unable to determine its contents, other than it would have to be some component with measurable prices.
changing apart from the influenced one. The ‘+’ sign indicates a positive influence, which means that, *ceteris paribus*, an increase in the influencing variable causes an increase in the influenced one (a decrease causes a decrease). Similarly ‘−’ points to a negative influence, which means that, *ceteris paribus*, an increase in the influencing variable causes an decrease in the influenced one (a decrease causes an increase).

A causal diagram like figure 4 can be formally described as a directed signed graph. One of the authors, Selten (1967), has used such structures to describe the mental models of subjects in oligopoly experiments. Causal diagrams seem to be near to natural verbal reasoning about economic policy questions. This makes them useful as an expository device of what can and cannot be concluded on the basis of purely qualitative features of a model like the one presented here.

1.7.2. *Explanation of the links*

For the sake of clarity figure 4 is less detailed than the full equation system of the model. It corresponds to a condensed version of this system obtained by the elimination of some less important variables. (The condensed system is introduced in section 3.2). Therefore some explanations of the links in figure 4 will be given now.

In our model, the exchange rate \( e \) is the local currency price of one unit of a basket of foreign currencies. Thus when there is a devaluation of the local currency, \( e \) increases. If this happens \( p_0 \), the local currency price of imports, increases. The wholesale price \( p_1 \), obtained from \( p_0 \), through the application of

a fixed mark-up factor, also increases. Thus \( e \) has a positive influence on \( p_1 \), the wholesale price of imports.

The positive influence of the exchange rate \( e \) on the local currency price of rural goods \( r \) suggests that if the foreign currency world market price of rural goods \( r^* \) remained unchanged after a devaluation (i.e. an increase in \( e \)), the local currency price of rural goods \( r \) would increase \textit{ceteris paribus}. (Actually \( r^* \) would not remain unchanged after such an increase in \( e \).)

The wholesale price of imports, \( p_1 \), and the price of rural goods, \( r \), both have positive influences on the retail price of local manufactures \( q \) since both enter per unit manufacturing variable costs on which \( q \) is set according to a fixed mark-up factor. The wholesale price of imports \( p_1 \) also has a positive influence on the retail price of imported goods \( p \), again because these two prices are linked by a fixed mark-up factor.

Because of gross substitutability, \textit{ceteris paribus}, an increase in the retail price of imported goods \( p \) decreases consumption of imported goods and increases domestic consumption of both services \( S \) and local manufactures \( Q \). This is the interpretation of the influences exerted by \( p \), the retail price of imported goods on \( P \), total quantity of imports, on \( S \), the total amount of services and on \( Q \), total output of manufactures. For similar reasons, \textit{ceteris paribus}, the retail price of manufactures \( q \) has a negative influence on total output of manufactures \( Q \) and positive influences on the total amount of services \( S \) and on total imports \( P \).

The total output of local manufactures \( Q \) has a positive influence on total imports \( P \) in that imported goods are used by manufacturing as variable inputs. Since rural goods are variable inputs too, more of them are needed for manufacturing if \( Q \) is increased, and therefore less are left over for exports. Accordingly \( Q \) has a negative influence on the quantity of exports \( X \). The foreign currency world market price of rural goods \( r^* \) is lower, the higher exports are. The quantity of exports, \( X \), has a negative influence on \( r^* \). \textit{Ceteris paribus}, (i.e. if the exchange rate remains unchanged) an increase in \( r^* \) leads to an increase in the local currency price of rural goods, \( r \). The influence of \( r^* \) on \( r \) is positive.

1.7.3. \textit{Causal chains}

After having commented on the links in the causal diagram – the \textit{ceteris paribus} direct impacts of the influencing variables – we now introduce some further terminology in order to facilitate the description of the channels along which the exchange rate exerts indirect influences on the output of local manufactures. We shall in the following refer to the influences represented by links in the diagram as direct influences in order to avoid them from being confused with these indirect influences.

A causal chain, in brief a chain, is a sequence of variables \( Z_1, \ldots, Z_m \) such that each of the \( m - 1 \) preceding variables \( Z_1, \ldots, Z_{m-1} \) has a direct influence on the next one. When we speak of the indirect influence of \( Z_1 \) on \( Z_m \) along the chain \( Z_1, \ldots, Z_m \), we mean the impact of \( Z_1 \) on \( Z_m \) through the entire set of
influences in this chain, but only in this chain – the impact \( Z_1 \) would have on \( Z_m \) if there were no direct influences outside this chain.

If we want to examine whether an increase in \( Z_1 \) leads to an increase or decrease in \( Z_m \), we can look sequentially at the sign of one link in the chain after the other in order to determine the overall direction of change effected in \( Z_m \) by the entire set of links. When there is a minus sign, denoting a negative direct influence, the direction of change is reversed in the sense that the next variable moves in the opposite direction to the previous one. Two such reversals cancel each other out. Thus an increase in \( Z_1 \) leads to an increase in \( Z_m \) if the number of negative direct influence links in the chain is even, and to a decrease otherwise. Accordingly, we call a chain and the indirect influence associated with it positive if the number of direct negative influence links in the chain is even, and negative if this number is odd.

1.7.4. Indirect influences of the exchange rate on local manufacturing output

In figure 4 we find three causal chains from the exchange rate \( e \) to the total output of local manufactures \( Q \), through the wholesale price of imports, \( p_1 \), the retail price of imports, \( p \), the price of manufactures, \( q \), and the price of rural goods, \( r \):

1. Import competition chain: \( e \rightarrow p_1 \rightarrow p \rightarrow Q \)
2. Imported inputs cost chain: \( e \rightarrow p_1 \rightarrow q \rightarrow Q \)
3. Exportables input cost chain: \( e \rightarrow r \rightarrow q \rightarrow Q \)

The names are meant to be suggestive of the interpretations. The import competition chain is positive. A devaluation (an increase in \( e \)) raises \( p_1 \), the wholesale price of imports and thereby also \( p \), the retail price of imports. Therefore ceteris paribus (i.e. disregarding the influence of \( q \) on \( Q \) through the imported and exportable input cost chains) less imported goods and more local manufactures are consumed. The assumption of gross substitutability has the consequence that imports and manufactures compete with each other in this sense.

The two input cost chains are negative. Ceteris paribus a devaluation (an increase in \( e \)) increases the wholesale price of imports \( p_1 \), and increases the price of rural goods \( r \). Since both these prices enter the per unit variable costs of manufacturing, a devaluation increases the retail price of local manufactures \( q \). Ceteris paribus an increase in \( q \) lowers total output of manufactures \( Q \).

The import competition chain is in agreement with the traditional view. However, as we show in 3.4 and later again in 3.17, in our model an increase in \( e \) results in a decrease in \( Q \). This seems to suggest that the combined indirect influences along the two input cost chains affecting the retail price of local manufactures \( q \) through its wholesale input prices \( p_1 \) and \( r \) are stronger than that of the import competition chain affecting the retail price of imports \( p \) through its wholesale input price \( p_1 \). Actually the situation is not quite so simple. In order to facilitate the explanation of this we introduce some further terminology.
1.7.5. *Loops*

A ‘loop’ is a sequence of variables $Z_1, \ldots, Z_m$ with $Z_m = Z_1$ that otherwise satisfies the conditions of a chain. This means that $Z_1, \ldots, Z_{m-1}$ and $Z_2, \ldots, Z_m$ are chains. Like a chain a loop is called positive, if the number of negative direct influences on it is even, and negative if this number is odd. A causal diagram is called balanced if it has no negative loops and if in addition to this for every pair of two variables $U$ and $V$ the chains from $U$ to $V$ (if there are any) are either all positive or all negative. Otherwise the causal diagram is unbalanced. An exogenous variable is a variable on which no other variable has a direct influence. Other variables are called endogenous.

The exchange rate $e$ is an exogenous variable, the only one in figure 4. The significance of balance lies in the fact that a balanced causal diagram permits unambiguous conclusions about the effect of a change in an exogenous variable on each of the endogenous variables. As we have seen in figure 4 two negative chains and one positive chain lead from $e$ to $Q$. This alone makes the causal diagram of figure 4 unbalanced. Further, a loop can be found in figure 4.

Loop:

$$
\begin{align*}
Q & \rightarrow X \rightarrow r^* \rightarrow r \rightarrow q \rightarrow Q
\end{align*}
$$

This loop is negative. The causal diagram in figure 4 satisfies neither the first nor the second condition of balance. In a part of the parameter space, the presence of this loop has the consequence that an increase in the exchange rate $e$ results in a decrease in the local currency price of rural goods $r$ in spite of the fact that it leads to a decrease in local manufactures $Q$ in the whole parameter space (see sections 3.17 and 3.18). Here the negative loop is stronger than the direct influence of $e$ on $r$, but the import input cost chain is strong enough to overcome the combined forces of the negative loop and the negative import competition chain.

1.7.6. *Description of the results by balanced causal diagrams*

A purely qualitative reasoner faced with beliefs described by an unbalanced causal diagram may try to arrive at a balanced one to reach a definite conclusion by eliminating sufficiently many direct influences judged to be relatively unimportant. We shall now do something similar based on the results of the analysis of our model. Figures 5 and 6 show balanced causal diagrams for the two cases, that of a positive impact of $e$ on $r$, and that of a negative impact of $e$ on $r$.

These causal diagrams summarise the qualitative features of our results. In both cases $e$ has a positive indirect influence on $p_1$, $p$, $q$, $S$ and $X$, and a negative one on $P$, $Q$ and $r^*$. The price $r$ of rural goods is the only variable for which the indirect influence of $e$ is different in the two diagrams.

Comparing the balanced causal diagrams of figures 5 and 6 with the unbalanced causal diagram of figure 4 also reveals which direct influences are dominated by others that go in the opposite direction. In both figures 5 and 6 the direct influences of $q$ on $P$ and of $p$ on $Q$ are eliminated. In our model such cross price effects on consumption emerge as less important than direct price effects. In figure 5 the loop is broken for rural goods prices by the
elimination of the direct influence of the foreign currency $r^*$ on the local currency price $r$. This means that the change in $r^*$ is too small to be decisive for the direction of change in $r$. In figure 6 the direct influences of $e$ on $r$ and...
of $r$ on $q$ are eliminated. In this case the direct influence on $r$ is dominated
by the indirect one that goes through the long negative chain $e, p_1, q, Q, X,$
$r^*, e$.

1.7.7. Results not included in the causal diagram

Further results concern variables not included in the causal diagrams. If export
demand is elastic, an increase in $e$ improves the trade balance in foreign
currency, as one would expect on the basis of traditional theory. A devaluation
also improves the trade balance in the country’s home currency if the trade
balance is positive, but in the case of a negative trade balance, the effect of $e$
may be the opposite. The effect of $e$ on import penetration is ambiguous too.
The direction depends on the parameter constellation.

The indirect influence on most variables is unambiguous. The rural goods
price $r^*$ and import penetration and the trade balance in the country’s home
currency are the only exceptions. In these three ambiguous cases, by rough
estimates of model parameters based on Australian data, we try to check
whether the results are in agreement with empirical observations and we come
to a positive conclusion.

More detailed accounts of the results for particular variables are given
in sections 3.17 (manufacturing), 3.21 (rural goods), 3.24 (imported goods),
3.27 (services), 3.28 (trade balance) and 3.31 (import penetration).

2. THE MODEL

In this part we present our formal model. We begin with a list of variables
and parameters. Within the model, our distinction between variables and
parameters relates to their dependence on or independence from the exchange
rate. Variables change because of an exchange rate change (and the exchange
rate is also a variable), whereas parameters are unaffected by exchange rate
changes.

2.1. Variables and parameters

2.1.1. Total quantities

$P$, imported goods.
$Q$, local manufactures.
$R$, rural goods (agricultural, pastoral and mining).
$S$, services.

2.1.2. Input quantities

$M_F$, exogenously fixed inputs of $M$ into industries other than $M$, $M = P, Q,$
$R, S$.
$M_Q$, variable inputs of $M$ into the production of manufactures, $M = P, R$. 

2.1.3. **Input parameters**

\( a \), variable inputs of imported goods per unit of manufactures.

\( b \), variable input of rural goods per unit of manufactures.

\( m \), variable labor costs per unit of services.

2.1.4. **Export and consumption quantities**

\( X \), exports of rural goods.

\( M_C \), consumption of \( M, M = P, Q, S \).

2.1.5. **Prices in local currency**

\( p_0 \), landed price of imported goods.

\( p_1 \), wholesale price of imported goods.

\( p \), retail price of imported goods.

\( q \), price of manufactured goods (retail).

\( r \), price of rural goods (wholesale).

\( s \), price of services (retail).

\( e \), exchange rate, price of one unit of a foreign currency basket in local currency, (i.e. \( e \) goes down when the local currency appreciates against this basket of foreign currencies).

2.1.6. **Prices in foreign currency**

\( p^* \), landed price of imported goods (world market price at the border).

\( r^* \), price of rural goods (world market price at the border).

\( q^* \), foreign currency equivalent of \( q \).

2.1.7. **Mark-up factors**

\( g \), wholesale mark-up factor for imported goods.

\( h \), retail mark-up factor for imported goods.

\( k_T \), compound mark-up factor for \( T = P, Q, S \) with \( k_P = g h \).

2.2. **Assumptions**

In the following we introduce the assumptions underlying our model.

2.2.1. **Production**

\[
P_Q = aQ \quad (1)
\]

\[
R_Q = bQ \quad (2)
\]
The input coefficients $a$ and $b$ are constant. As discussed in section 1.5, $P_Q$ and $R_Q$ are the only variable inputs into the manufacturing sector. Labour inputs into the manufacturing and import sectors are fixed. In the service sector, however, labour is the only variable input and all other inputs are fixed. Imports are the only variable input into the import sector.

The total quantity $R$ of rural goods is exogenously given. In view of this, all inputs into the rural sector are treated as fixed.

2.2.2. Balance equations

$$P = P_F + P_Q + P_C$$ (3)

recalling that $P$ is the total amount of imports, $P_F$ is the amount of imports that are fixed inputs into other industries, $P_Q$ the amount of imports that are variable inputs into manufacturing, and $P_C$ is the amount of imports that are consumer goods.

$$Q = Q_F + Q_C$$ (4)

recalling that $Q$ is the total amount of manufactures, $Q_F$ is the amount of manufactures that are fixed inputs into other industries and $Q_C$ is the amount of manufactures that are consumer goods.

$$R = R_F + R_Q + X$$ (5)

recalling that $R$ is the total amount of rural goods, $R_F$ is the amount of rural goods that are fixed inputs into other industries, $R_Q$ the amount of rural goods that are variable inputs into local manufacturing, and $X$ is the amount of rural goods that are exports.

$$S = S_F + S_C$$ (6)

recalling that $S$ is the total amount of services, $S_F$ is the amount of services that are fixed inputs into other industries and $S_C$ the amount of services that are consumer goods.

2.2.3. Domestic consumption demand

There is direct consumption demand for imported goods, local manufactures and services, but not for rural goods. Consumption goods made of agricultural, pastoral or mining products are processed by the manufacturing sector before they are sold to consumers.

In the time span under consideration, consumption demand does not respond to changes in profits and wages. Consumption demand depends on prices according to a ‘predetermined’ demand schedule:

$$P_C = D_P(p, q, s)$$ (7)

$$Q_C = D_Q(p, q, s)$$ (8)

$$S_C = D_S(p, q, s).$$ (9)
The word ‘predetermined’ expresses independence of the exchange rate. The prices $p$ and $q$ are influenced by $e$, but not the functions $DP, DQ$ and $DS$. Assumptions on the shape of these functions will be introduced later.

2.2.4. Export demand

$$r^* = \varphi(X)$$  \hspace{1cm} (10)

$\varphi$ is continuously differentiable with $\varphi(X) > 0$ and

$$\varphi' = \frac{d\varphi(X)}{dX} < 0$$

for all $X = 0$.

2.2.5. Relationship between domestic and foreign currency prices

$$p_0 = p^* e$$  \hspace{1cm} (11)

$$r = r^* e$$  \hspace{1cm} (12)

$$q = q^* e$$  \hspace{1cm} (13)

Equation (13) is the definition of $q^*$, the foreign money equivalent of $q$.

2.2.6. Domestic price formation

$$p_1 = gp_0$$  \hspace{1cm} (14)

$$p = hp_1$$  \hspace{1cm} (15)

$$q = kQ(ap_1 + br)$$  \hspace{1cm} (16)

$$s = kSm$$  \hspace{1cm} (17)

recalling that $m$ is variable labour costs per unit of services.

Comment

Domestic prices are formed by applying fixed mark-up factors to variable unit costs. If the firms in an industry are operating in a market with monopolistic competition, in which all of them face firm demand functions with the same constant elasticity, then this kind of pricing is the theoretical consequence of profit maximisation. However, the assumption that prices are obtained by mark-ups on marginal costs may also be thought of as describing a behavioural rule.

As discussed in section 1.5, for imported goods and manufactures only material inputs enter variable unit costs. These are the imported goods themselves in the case of wholesaling and retailing of imported goods. In the case of manufacturing the only variable inputs are imported goods and rural goods. Imported goods are bought by wholesalers of imported goods at $p_0$, the price in local currency, and then sold to manufacturers or to retailers of imported goods at the wholesale price $p_1$. The retailers of imported goods sell to consumers at the retail price $p$.
The only variable input into the provision of services is labour. By contrast, labour inputs into other industries are assumed to be fixed. We do not explicitly model which fixed inputs are needed by which industry, only the total quantities $P_F, Q_F$ and $S_F$ of fixed inputs of imported goods, manufactures and services that are required by other industries. These quantities also include inputs into activities exogenous to our model, government purchases and private investment. A more detailed modelling is not necessary for the questions being examined here. It is clear that the unit variable costs are $p_0$ for the wholesaling of imported goods, $p_1$ for the retailing of imported goods, $ap_1 + br$ for manufactured goods and $m$ for services.

The inputs into the production of rural goods are all treated as fixed, even if they may be partially variable with respect to the production function. This is justified by the assumption that the total output $R$ of rural goods is exogenously given.

We do not explicitly split manufacturing into the three layers, production, wholesaling and retailing. This is not necessary, since it does not matter for the formation of $p$ and $s$ at which prices the fixed inputs of manufactures are bought by wholesalers and retailers of imported goods or by providers of services. Similarly there is no need for a more detailed model of the provision of services.

2.2.7. Notation: Elasticities and quasi-elasticities

\[ e^* = \varphi'(X) \frac{X}{p^*} \]

inverse export elasticity.

\[ D_{My} \]

partial derivative of consumption demand for good $M$, $D_M(p, q, s)$ with respect to $y$, $M = P, Q, S$ and $y = p, q, s$.

\[ \varepsilon_{My} = D_{My} \frac{y}{MC} \]

elasticity of $MC$ with respect to $y$, $M = P, Q, S$ and $y = p, q, s$.

\[ \eta_{My} = D_{My} \frac{y}{M} \]

quasi-elasticity of $MC$ with respect to $y$, $M = P, Q, S$ and $y = p, q, s$.

Elasticities are not assumed to be constant. The elasticities $\varepsilon_{My}$ are functions of $p, q$ and $s$. The quasi-elasticities $\eta_{My}$ are the same as the elasticities $\varepsilon_{My}$ except that the retail price $y$ is denominated by the total amount $M$ rather than by the consumption amount $MC$. Such quasi-elasticities are useful since they permit shorter formulas.

2.2.8. Assumptions on domestic demand

1. Positiveness and differentiability.

For $M = P, Q, S$, the function $D_M(p, q, s)$ is positive and continuously differentiable at every triple of positive prices $p, q, s$. 

2. Boundedness of expenditures for manufactures.
   There are positive numbers $A$ and $B$ with
   \[ A < qD_Q(p,q,s) < B \]
   for every triple of positive prices $p, q, s$.

The matrix of elasticities. The next two assumptions concern the matrix of elasticities:

\[
\varepsilon = \begin{pmatrix}
\varepsilon_{PP} & \varepsilon_{PQ} & \varepsilon_{PS} \\
\varepsilon_{QP} & \varepsilon_{QQ} & \varepsilon_{QS} \\
\varepsilon_{SP} & \varepsilon_{SQ} & \varepsilon_{SS}
\end{pmatrix}
\]

   The off-diagonal elements of $\varepsilon$ are positive.

   The row sums $\varepsilon_{MP} + \varepsilon_{MQ} + \varepsilon_{MS}$ are negative for $M = P, Q, S$.

Remarks
It follows from 3. and 4. that the diagonal elements of $\varepsilon$ are negative. Analogous to $\varepsilon = (\varepsilon_{MM})$ we can form a matrix $\eta = (\eta_{MM})$ of quasi-elasticities. Obviously this matrix too has positive off-diagonal elements, negative row sums and negative diagonal elements.

Interpretation
Continuous differentiability is a technical assumption that hardly needs any comment. The requirement of positive demands for all positive price triples is somewhat less technical, since it excludes demand for a commodity becoming zero at a very high relative price, but it may not be very important whether it really becomes zero or only extremely small. The assumption of a lower bound on expenditures for manufactures is only a little stronger than that. The assumption of an upper bound is a reasonable one; it is satisfied if total expenditures are fixed or at least bounded from above.

Gross substitutability means that there are substitutional relationships between $P_C, Q_C$ and $S_C$ that are stronger than other influences like income effects, which may arise if only one price is changed. This seems to be reasonable for broad aggregates like those considered here. The name ‘non-inferiority’ for assumption 4. is motivated by the following interpretation. Suppose that all three prices $p, q$ and $s$ are decreased by the same percentage. The new prices are $k_p, k_q$ and $k_s$ with $k < 1$. Such a price decrease is an increase in real income. Therefore we may say that all three commodities – imported goods, manufactures, services – are non-inferior if $P, Q$ and $S$ are all increased by such a price decrease. It can be seen without difficulty that we have:

\[
\frac{\partial D_M(\lambda_p, \lambda_q, \lambda_s)}{\partial \lambda} = M_C[\varepsilon_{MP} + \varepsilon_{MQ} + \varepsilon_{MS}] \quad \text{for } M = P, Q, S
\]

where $e_{M_0}$ stands for the value of the elasticity at $\lambda p, \lambda q, \lambda s$. This shows that the negative row sums are necessary and sufficient for the non-inferiority of the three goods.

2.2.9. **Constraints on variables and parameters**

We refer to equations (1) to (16) as the full system of model equations, in brief as the full system. The full system has the following 17 variables: $p, q, s, p_0, q_0, r_0, p_1, q_1, s_1$. All these variables are assumed to be positive. The full system has 12 parameters: $a, b, g, h, s, k_0, p_0, q_0, r_0, q_0^*, r_0^*$ and $e$. Without this inequality, positive values for $Q_c$ and $X$ would not be feasible. A constellation of parameters is admissible if it satisfies all the constraints stated above.

3. **Analysis**

3.1. **Plan of the analysis**

A solution of the full system is an assignment of positive values to the 17 variables such that the equations (1) to (16) are satisfied. As we shall see, a lower limit $e_0$ for the exchange rate exists such that the choice of a value for $e$ in the range $e > e_0$ uniquely determines a solution of the full system with this value for $e$. At values of $e$ with $e = e_0$, the full system does not have a solution in the sense defined above because exports would have to be zero for $e = e_0$.

The solutions form a curve segment in the 17-dimensional space of the variables of the full system. Along this curve segment all other variables can be thought of as functions of $e$. We refer to this curve segment as the equilibrium curve of the full system. The use of the word equilibrium is motivated by the idea that a solution describes a short-to-medium run equilibrium of the system. It is our goal to examine the effects of changes of $e$ along this equilibrium curve.

We first shall eliminate some variables. Thereby we obtain a ‘condensed system’. This condensed system has the same variables as the causal diagram discussed in the introduction. A part of the condensed system will be further...
reduced to a system of two equations and one inequality. We call this small system the ‘core system’. With the help of the core system the existence of a uniquely determined solution can be established. It will then be possible to examine the effects of a change in $e$ along the equilibrium curve by taking total differentials of all equations of the condensed system.

3.2. The condensed system

We eliminate the variables $P_Q, R_Q, P_C, Q_C, S_C$, and $p_0$ and thereby obtain the following condensed system:

\[
P = P_F + aQ + D_P(p, q, s) \tag{18}
\]
\[
Q = Q_F + D_Q(p, q, s) \tag{19}
\]
\[
R = R_F + bQ + X \tag{20}
\]
\[
S = S_F + D_S(p, q, s) \tag{21}
\]
\[
r^* = \varphi(X) \tag{22}
\]
\[
p_1 = gp^*e \tag{23}
\]
\[
r = er^* \tag{24}
\]
\[
p = hp_1 \tag{25}
\]
\[
q = k_Q(ap_1 + br) \tag{26}
\]

The condensed system comprises nine equations for the 10 variables $P, Q, S, X, p_1, p, q, r, r^*$ and $e$. A solution of the condensed system is an assignment of positive values to these variables such that equations (18) to (26) are satisfied. It is clear that a solution of the condensed system uniquely determines positive values for the remaining variables $P_Q, R_Q, P_C, Q_C, S_C$, and $p_0$ such that (1) to (16) are satisfied. In this way a solution of the condensed system generates a uniquely determined solution of the full system.

3.3. Demand and supply

In the following we shall transform (19) and (26) into a demand equation for local manufacturing output $Q$ and a supply equation for the price of local manufacturing $q$. These equations will contain no other variables than $Q, q$ and the exchange rate $e$. In view of (25) and (23) we can replace $p_1$ by $gp^*e$ and $p$ by $ghp^*e$. Moreover it follows from (24) that $r^*e$ can be inserted for $r$ in (26). The balance equation (20) yields:

\[
X = R - R_F - bQ. \tag{27}
\]
With the help of (22) we obtain:

\[ r^* = \varphi(R - R_F - bQ). \] (28)

With these replacements (19) and (26) are transformed into the following relationships:

**Demand:**

\[ Q = Q_F + D_Q(g h p^* e, q, s) \] (29)

**Supply:**

\[ q^* = e k_Q[a g p^* + b \varphi(R - R_F - bQ)]. \] (30)

For the purpose of finding the solution as far as the variables \(Q\) and \(q\) are concerned, one has to take account of the assumption that exports are positive. This means that in addition to (29) and (30) the condition has to be imposed that the right-hand side of (27) is positive. The condensed system could be reduced in this way. However, as we shall see, this very natural approach does not determine the net effect of a devaluation on the quantity of manufactures. Therefore a more convenient reduction, the core system, will be introduced in the next section.

For fixed \(e\) we can look at (29) and (30) as a demand curve and a supply curve in a diagram with \(Q\) as the abscissa and \(q\) as the ordinate. In view of \(\varepsilon_{Qq} < 0\) and \(\varphi' < 0\), the slope of the demand curve is negative and that of the supply curve is positive.

The rising supply curve is due to the assumption that the country is big on its export markets. At a fixed exchange rate \(e\) an expansion of \(Q\) the quantity of local manufactures, must be accompanied by a reduction of rural output, a rise of world market prices, an increase in the cost of imported and exportable inputs, and therefore by an increase in the price of local manufactures \(q\).

Figure 7 illustrates the effects of an increase in \(e\) that is a devaluation. Demand for local manufactures shifts upward in view of \(D_Q e > 0\). The devaluation increases the price of imports and thereby weakens import competition to local manufactures. However, the supply curve is also shifted upward, since the prices of imported and exportable inputs are raised. Nothing definite can be said on the joint effect of both shifts on the point of intersection of the demand and supply curves. Figure 7 shows the case of a dominant contractionary effect of the supply curve shift. As we shall see, in our model the contractionary effect is always dominant, but this cannot be deduced by looking at shifts of supply and demand in the usual way.

### 3.4. The core system

The difficulty discussed in the last section can be overcome by looking at the foreign money equivalent \(q^*\) of \(q\), defined by (13), as the price variable that determines the demand \(Q\) for local manufactures. In view of \(q^* = q/e\), it can be seen immediately with the help of (30) that \(q^*\) does not depend on \(e\). Replacing \(q\) by \(q^* e\) in (29) and (30) yields (31) and (32). These equations have to be
complemented by inequality (33) that requires that the right-hand side of (29) is positive. In this way we take account of the assumption that exports $X$ are positive. The equations (31) and (32) together with the inequality (33) constitute the ‘core system’.

Quasi-demand:

$$Q = Q_F + D_Q(ghp^* e, q^* e, s).$$

(31)

Quasi-supply:

$$q^* = k_Q[agp^* + b\varphi(R - R_F - bQ)].$$

(32)

Rural goods limit:

$$R > R_F + bQ.$$  

(33)

Figure 8 shows the effect of a devaluation in a diagram with $Q$ on the abscissa and $q$ on the ordinate. We shall prove that a devaluation causes a downward shift of the quasi-demand curve, but this is by no means obvious. We have

$$D_{Qp} > 0$$

(34)

$$D_{Qq} < 0.$$  

(35)
Therefore, a devaluation has two opposite effects on quasi-demand, one via the first and one via the second argument of $D_Q$. It needs to be shown that the effect via $q = q^* e$ is the stronger one.

3.5. Properties of quasi-demand and quasi-supply

A solution of the core system is a triple $(e, Q, q^*)$ such that for this triple (31), (32) and (33) are satisfied. It can be seen immediately that $(e, Q, q^*)$ is a solution of the core system if and only if the quasi-supply curve and the quasi-demand curve for this $e$ intersect to the left of the vertical line $Q = Q_0$ at the point $(Q, q^*)$. We have to examine for which exchange rates $e$ this is the case. Before we do this, we derive the following results about the quasi-supply and quasi-demand curves:

(a) The quasi-supply curve is increasing for all $Q = 0$.
(b) For every $e$ the quasi-demand curve is falling.
(c) An increase in $e$ always shifts the quasi-demand curve to the left.
(d) For every $e$ the $Q$-axis and the vertical line $Q = Q_F$ are asymptotes of the quasi-demand curve.
(e) For every $e$ let $u(e)$ be the value of $q^*$ at the intersection point of the quasi-demand function with the vertical line $Q = Q_0$. The function $u(e)$ is continuous, decreasing and positive everywhere. The function $u(e)$ approaches the limit 0 for $e \to \infty$ and $\infty$ for $e \to 0$.
(f) For every $e$ the quasi-demand curve has a unique intersection with the quasi-supply curve.

Assertion (a) is an immediate consequence of $b > 0$ and $\varphi' < 0$. Property (b) of quasi-demand curves follows from $\varepsilon_{Oq} < 0$. To prove (c), we form the partial derivative of the right-hand side of (31).

$$\frac{\partial Q}{\partial e} = ghp^* D_{Qp}(ghp^* e, q^* e, s) + q^* D_{Qp}(ghp^* e, q^* e, s).$$

(36)

This can be rewritten as follows:

$$\frac{\partial Q e}{\partial e} = \eta_{Qp} + \eta_{Oq}$$

(37)

with values of the quasi-elasticities at $(ghp^* e, q^* e, s)$. In view of gross substitutability and the non-inferiority assumption on consumption demand elasticities, we can conclude that $Q$ and also $Q_C = Q - Q_F$ are decreasing functions of $e$ for fixed $q^*$. This together with (b) yields (c).

The boundedness assumption on consumption demand expenditures for local manufactures yields:

$$A < q^* e Q_C < B$$

(38)

with

$$Q_C = D_Q(ghp^* e, q^* e, s).$$

(39)

For fixed $e$ and $q^* \to 0$, the consumption demand $Q_C$ grows without limit because of the boundedness of $q^* e Q_C$ from below; for $Q_C \to \infty$ we must have $q^* \to 0$ because of the boundedness of $q^* e Q_C$ from above. This shows that the $Q$-axis is an asymptote of the quasi-demand curve. For fixed $e$ and $q^* \to \infty$, we must have $Q_C \to 0$ because of the boundedness of $q^* e Q_C$ from above; for $Q_C \to 0$, we must have $q^* \to \infty$ because of the boundedness of $q^* e Q_C$ from below. This shows that the vertical line $Q = Q_F$ is an asymptote of the quasi-demand curve. Therefore (d) holds.

Since $D_Q$ is continuous, it follows from (b) and the fact that the $Q$-axis is an asymptote of the quasi-demand curve that this curve has an intersection with the line $Q = Q_0$ at a value $u(e)$ of $q^*$ that continuously depends on $e$. This proves (e) and part of (f).

It follows from (38) that we have

$$A < eu(e)Q_0 < B.$$  

(40)

The boundedness assumption on consumption demand expenditures for local manufactures from above yields $u(e) \to 0$ for $e \to Q_F$ and its boundedness from below leads to $u(e) \to 0$ for $e \to 0$. In view of (e), the function $u(e)$ is decreasing. We have shown (e).

In view of (d), the quasi-demand curve is above the quasi-supply curve for small values of $Q_C$, and below the quasi-supply curve for large values of $Q_C$. This together with (b) yields (f).
Let \( u_0 \) be the value of \( q^*/c3 \) on the quasi-supply curve for \( Q = Q_0 \). It follows from (b) and (e) that the equation

\[
u(e_0) = u_0
\]

has a unique solution \( e_0 \). The quasi-demand curve for \( e_0 \) intersects the quasi-supply curve at \((Q_0, u_0)\).

### 3.6. The solution range

We use the symbol \( Q(e) \) for the value of \( Q \) at the intersection of the quasi-demand curve for \( e \) with the quasi-supply curve. Similarly \( q^*(e) \) is the value of \( q^* \) at this intersection. The solution of (41) satisfies

\[
Q(e_0) = Q_0.
\]

Since an increase in \( e \) shifts the quasi-demand curve to the left, we have

\[
Q(e) < Q_0 \quad \text{for} \quad e > e_0
\]

and

\[
Q(e) \geq Q_0 \quad \text{for} \quad e \leq e_0.
\]

This shows that the core system has the solution \((e, Q(e), q^*(e))\) for every \( e \) with \( e > e_0 \) and that no solution \((e, Q(e), q^*(e))\) with \( e = e_0 \) exists. We call the set of all \( e \) with \( e > e_0 \) the ‘solution’ range and the ‘border exchange rate’.

**Result**

A border exchange rate \( e_0 > 0 \) exists such that for \( e > e_0 \) the exchange rate \( e \) together with the intersection point \((Q(e), q^*(e))\) of the quasi-supply curve and the quasi-demand curve for \( e \) forms a solution \((e, Q(e), q^*(e))\) of the core system. There are no solutions of the core system with exchange rates \( e \) outside the solution range \( e > e_0 \).

### 3.7. Properties of \( Q(e) \) and \( q^*(e) \)

Since a devaluation, an increase in \( e \), shifts the quasi-demand curve to the left, \( Q(e) \) is a decreasing function of \( e \). Moreover, since the quasi-supply curve is rising, \( q^*(e) \) is a decreasing function of \( e \) too.

We now want to argue that \( Q(e) \) and \( q^*(e) \) are differentiable functions of \( e \). In order to show this with the help of the implicit function theorem (see Ostrowski, 1968, pp. 200–204), we have to rearrange (31) and (32) such that the right-hand sides become zero. The left-hand sides are then looked upon as functions of \( Q, q^* \), and \( e \).

\[
F_1(Q, q^*, e) = Q - Q_F - D_Q(ghp^*e, q^*e, s)
\]

\[
F_2(Q, q^*, e) = q^* - k_Q[agp^* + b\varphi(R - R_F - bQ)]
\]

For $i = 1, 2$, let $F_{iQ}$ and $F_{iq}$ be the partial derivatives of $F_i$ with respect to $Q$ and $q$. In view of the continuous differentiability of $DQ$ and $\varphi$, those derivatives exist and are continuous. Under these conditions it is sufficient for the differentiability of $Q(e)$ and $q^*(e)$ that the matrix

$$F = \begin{pmatrix} F_{1Q} & F_{1q} \\ F_{2Q} & F_{2q} \end{pmatrix}$$

has a non-vanishing determinant. We have

$$F = \begin{pmatrix} 1 & -eD_{Qq} \\ k_0b^2\varphi' & 1 \end{pmatrix}$$

where for the sake of brevity the arguments of $D_{Qq}$ and $\varphi'$ are omitted. The determinant of $F$ is as follows

$$|F| = 1 + k_0b^2e\varphi'D_{Qq}.$$  

Since $\varphi'$ and $D_{Qq}$ are both negative, the right-hand side is positive. We can conclude that $Q(e)$ and $q^*(e)$ are differentiable functions of $e$.

3.8. Comment

The concept of a solution as defined above requires that exports be positive. At exchange rates smaller than the border exchange rate exports would have to be negative (i.e. rural goods would be imported). An extension of the model, which allows for this possibility, would entail cumbersome case distinctions we choose to avoid since we are interested in movements of the exchange rate within the solution range only.

We have already obtained an important result, namely that an increase in $e$ (a devaluation) decreases the output of local manufactures $Q$. This is due to a shift of the quasi-demand curve to the left. As can be seen from (37), the dominance of own price elasticity over cross price elasticities is responsible for the shift to the left. The reason for this is that with an unchanging foreign currency price of local manufactures $q$, an increase in $e$ increases by the same percentage both $p$ and $q$, the retail prices in local currency of imports and local manufactures.

If $q^*$ were to remain unchanged, the effect on manufacturing output would be stronger than it actually is. The indirect negative influence of $Q$ via $r^*$ on $q^*$ mitigates the effect on $Q$ but does not reverse it. This indirect influence is reflected in the positive slope of the quasi-supply curve.

3.9. The equilibrium curve

Consider a solution $(e, Q(e), q^*(e))$ of the core system. From it we can determine a solution of the condensed system. For this purpose we first compute $q$ with the help of (13) and then $p_1$ and $p$ from (23) and (25). The price of services $s = kUm$ is not a variable, but rather a parameter of the condensed system. The variables $P$, $Q$, $X$, $S$, $r^*$ and $r$ can then be determined by (18),
(19), (20), (21), (22) and (24) respectively. All variables determined in this way are positive for every admissible parameter set, and all equations of the condensed system are satisfied by them. This is also valid for (26), which is nothing other than the quasi-supply curve multiplied by $e$. We use the notation $P(e)$, $S(e)$, $X(e)$, $p_1(e)$, $p(e)$, $q(e)$, $r(e)$ and $r^*(e)$ for the values of $P$, $Q$, $X$, $S$, $p_1$, $p$, $r$ and $r^*$ respectively obtained in this way. The vector

$$V(e) = (P(e), Q(e), S(e), X(e), p_1(e), p(e), q(e), r(e), r^*(e))$$

(50)

will be referred to as the equilibrium vector for $e$. The vectors $V(e)$ with $e > e_0$ form a curve segment in the 9-dimensional space of the variables. We call this curve segment the equilibrium curve. The use of the word 'equilibrium' in these definitions is motivated by the idea that $V(e)$ describes a short or medium run equilibrium of the economy.

Occasionally we shall also use the notation $P_Q(e)$, $R_R(e)$, $P_C(e)$, $Q_C(e)$, $S_C(e)$ and $P_Q(e)$ for the values of the corresponding variables determined by $V(e)$. Augmenting $V(e)$ at the end of this vector (i.e. after $r(e)$) with $q^*(e)$ and these functions, in this order, leads to a vector $W(e)$ that we refer to as the full equilibrium vector for the full system. The set of all $W(e)$ with $e > e_0$ is the equilibrium curve for the full system. However, we shall not make much use of this curve. Therefore, whenever we speak of the equilibrium curve without explicitly referring to the full system, we mean the set of $V(e)$ with $e > e_0$, in other words, the equilibrium curve for the condensed system.

As we have shown, $Q(e)$ and $q^*(e)$ are differentiable. It can be seen without difficulty therefore that all components of $W(e)$ are differentiable functions of $e$. The differentiability of the components of $V(e)$ enables us to conclude that the equilibrium curve has a tangent at every point $V(e_1)$ with $e_1 > e_0$. This will be of significance later. Analogously, the equilibrium curve for the full system has a tangent at every point $W(e_1)$ with $e_1 > e_0$.

3.10. The meaning of differentials

In order to investigate the effects of a change in $e$ we will take total differentials of all equations in the condensed system. Before we do this it is maybe useful to make some remarks about the interpretation of differentials. Consider the equilibrium vector at some given value $V(e_1)$ of the exchange rate. We look at the equations obtained by total differentials as a description of the tangent to the equilibrium curve at $V(e_1)$. For every variable $v$ of the condensed system, let $v_1$ be its value at $e_1$. Consider a point on the tangent to $V(e_1)$. For every variable $v$ of the condensed system, let $v_2$ be the value of $v$ at this point on the tangent. Then the equations obtained by taking total differentials of the condensed system hold with

$$dv = v_2 - v_1.$$  

(51)

In this way the differentials are interpreted as results of movements along the tangent.
The tangent interpretation of differentials is simple and adequate for our purposes. In more complex cases involving second derivatives, one has to give a more sophisticated meaning to differentials (Ostrowski, 1968, pp. 184–188.) The tangent interpretation has the virtue of being a good guide to one’s intuition.

3.11. The tangent system

We refer to the system obtained by taking total differentials of all equations in the condensed system as the tangent system. This name is suggested by its interpretation as the description of a tangent to the equilibrium curve. In our representation of the tangent system, we omit the arguments of $D_P, D_Q$ and $D_S$. These arguments are the prices $p(e_1)$ and $q(e_1)$ at a fixed but arbitrary point $V(e_1)$ with $e_1 > e_0$ and $s = k,s.m$. Similarly the argument $X(e_1)$ of $\phi'$ is omitted. We obtain the following tangent system:

\[ dP = a dQ + D_{p_P} dp + D_{p_Q} dq \]  
\[ dQ = D_{Q_P} dp + D_{Q_Q} dq \]  
\[ dX = -b dQ \]  
\[ dS = D_{S_P} dp + D_{S_Q} dq \]  
\[ dr^* = \phi' dX \]  
\[ dp_1 = g p^* de \]  
\[ dr = e dr^* + r^* de \]  
\[ dp = h dp_1 \]  
\[ dq = k_0 (a dp_1 + b dr). \]

The tangent system is a homogeneous linear system of nine equations for the 10 variables $dP, dQ, dX, dS, dp_1, dp, dq, dr, dr^*$ and $de$. The system contains no equation for $ds$, which is equal to zero, because $s$ is a parameter independent of the exchange rate.

3.12. Transition to relative differentials

For every variable $v$ we call $dv/v$ the relative differential of $v$. It is convenient to transform the equations of the tangent system in such a way that they become relations between relative differentials. For this purpose, we make use of the quasi-elasticities $\eta_{M_v}$. The definition of the quasi-elasticities at the beginning of section 2.2.7 yields

\[ \frac{D_{M_v} dy}{M} = \eta_{M_v} \frac{dy}{y} \]  

for $M = P, Q, S$ and $y = p, q, s$. Similarly from our definition of the inverse export price elasticity $\varepsilon^*$ also given at the beginning of section 2.2.7 above, we have

$$\varphi' = \frac{\varepsilon^* r^*}{X}. \tag{62}$$

These relationships are used in the reformulation of (52) to (56). Equations (57) to (60) are rewritten with the help of the corresponding equations (23) to (26). Moreover, for brevity and ease of interpretation, we replace $a Q$ by $P Q$ and $b Q$ by $R Q$ (in equations (1) and (2)). We also introduce the following notation in order to make the reformulation of (60) more transparent:

$$z = \frac{a p_1}{a p_1 + b r'}, \tag{63}$$

We call $z$ the import share of variable costs of local manufacturing, in brief the import share.

3.13. The relative tangent system

The following equations (64) to (72) form the relative tangent system:

$$\frac{d P}{P} = \frac{P Q}{P} \frac{d Q}{Q} + \eta Q_p \frac{d p}{p} + \eta Q_q \frac{d q}{q} \tag{64}$$

$$\frac{d Q}{Q} = \eta Q_p \frac{d p}{p} + \eta Q_q \frac{d q}{q} \tag{65}$$

$$\frac{d S}{S} = \eta S_p \frac{d p}{p} + \eta S_q \frac{d q}{q} \tag{66}$$

$$\frac{d X}{X} = -\frac{R Q}{X} \frac{d Q}{Q} \tag{67}$$

$$\frac{d r^*}{r^*} = \varepsilon^* \frac{d X}{X} \tag{68}$$

$$\frac{d p_1}{p_1} = \frac{d e}{e} \tag{69}$$

$$\frac{d r}{r} = \frac{d r^*}{r^*} + \frac{d e}{e} \tag{70}$$

$$\frac{d p}{p} = \frac{d p_1}{p_1} \tag{71}$$

$$\frac{d q}{q} = z \frac{d p_1}{p_1} + (1 - z) \frac{d r}{r}. \tag{72}$$

3.14. **Effect on the price of local manufactures**

We first observe that we have

\[ \frac{dp}{p} = \frac{dp_1}{p_1} = \frac{de}{e}. \] (73)

In the case of a change in \( e \), the wholesale and retail prices of imported goods change by the same percentage as \( e \). In view of (73), it follows from (70) and (72) that we have

\[ \frac{dq}{q} = \alpha \frac{de}{e} + (1 - \alpha) \left( \frac{d\eta^*}{\eta^*} + \frac{de}{e} \right). \] (74)

With the help of (67) and (68) this yields

\[ \frac{dq}{q} = \frac{de}{e} - (1 - \alpha)\eta^* \frac{RQ}{X} \frac{dQ}{Q}. \] (75)

Define

\[ \beta = -(1 - \alpha)\eta^* \frac{RQ}{X}. \] (76)

Since \( \eta^* \) is negative, \( \beta \) is positive. Instead of (75), we write

\[ \frac{dq}{q} = \frac{de}{e} + \beta \frac{dQ}{Q}. \] (77)

With the help of (65) and (73), this yields

\[ \frac{dq}{q} = \frac{de}{e} + \beta \left( \eta_{Qp} \frac{de}{e} + \eta_{Qq} \frac{dq}{q} \right) \] (78)

or equivalently

\[ \left[ 1 - \beta \eta_{Qq} \right] \frac{dq}{q} = \left[ 1 + \beta \eta_{Qp} \right] \frac{de}{e} \] (79)

Since \( \eta_{Qq} \) is negative the coefficient of \( dq/q \) is positive. We can divide by this coefficient and obtain

\[ \frac{dq}{q} = \gamma \frac{de}{e} \] (80)

with \( \gamma \) defined by

\[ \gamma = \frac{1 + \beta \eta_{Qp}}{1 - \beta \eta_{Qq}}. \] (81)

In view of gross substitutability, \( \eta_{Qp} \) is positive. Therefore \( \gamma \) is positive. It follows by the non-inferiority assumption that \( \eta_{Qp} \) is smaller than \( |\eta_{Qq}| \). Therefore the numerator of \( \gamma \) is smaller than the denominator. Consequently we have

\[ 0 < \gamma < 1 \] (82)
It follows from (80) and (82) that $|dq/q|$ is smaller than $|de/e|$. Since this is true for every tangent at a point on the equilibrium curve, we can conclude that an increase in $e$ within the range $e > e_0$ always results in an increase in $q$ by a smaller percentage. This is connected to the result found in the analysis of the core system that $q^*$ falls if $e$ rises. If $q^*$ were to remain unchanged, then $q$ and $e$ would rise by the same percentage, but since $q^*$ falls, $q$ must rise by a smaller percentage.

3.15. A manner of speaking

In the following we explain what we mean by two differentials having the same sign or opposite signs. The explanation will be based on the tangent interpretation of differentials discussed earlier.

If we speak of two differentials $dv$ and $dw$ having the same sign at $e$, we refer to a property of the tangent to the equilibrium curve of the full system at $W(e)$. We say that $dv$ and $dw$ have the same sign at $e$ if at every point on this tangent either both are positive, or both are negative, or both are zero. Similarly we say that $dv$ and $dw$ have opposite signs at $e$ if at every point on this tangent either one of the two differentials (it does not matter which one) is positive and the other is negative.

It can be seen easily that in the case of two variables $m$ and $w$ of the condensed system, it makes no difference whether we look at the relationship between $dv$ and $dw$ in the full system or in the condensed system. In this case the definition remains correct if the tangent to the equilibrium curve of the full system at $W(e)$ is replaced by the tangent to the equilibrium curve of the condensed system at $V(e)$.

Two differentials may have neither the same sign nor opposite signs at some $e$. Thus one of them may be positive while the other is zero. Moreover, two differentials may have the same sign in some parts of the range $e > e_0$ and opposite signs in others.

3.16. Effect on the quantity of manufacturing

The analysis of the core system has shown that $dQ$ and $de$ have opposite signs. Nevertheless we derive a formula for $dQ/Q$ as a function of $de/e$ that shows this again. We need this formula later.

With the help of (65), (73) and (80) we obtain

$$\frac{dQ}{Q} = (\eta_{Qp} + \gamma \eta_{Qq}) \frac{de}{e}. \quad (83)$$

In view of (81) we have

$$\eta_{Qp} + \gamma \eta_{Qq} = \eta_{Qp}(1 - \beta \eta_{Qq}) + \eta_{Qq}(1 + \beta \eta_{Qp}) \frac{1}{1 - \beta \eta_{Qq}} \quad (84)$$

or equivalently

\[ \eta_{Qp} + \gamma \eta_{Qq} = \frac{\eta_{Qp} + \eta_{Qq}}{1 - \beta \eta_{Qq}}. \]  

(85)

This yields

\[ \frac{dQ}{Q} = \frac{\eta_{Qp} + \eta_{Qq} \frac{de}{e}}{1 - \beta \eta_{Qq}}. \]  

(86)

In view of the non-inferiority and gross substitutability assumptions, the numerator of the coefficient of \( de/e \) in this equation is negative. Therefore \( dQ \) and \( de \) have opposite signs at every \( e > e_0 \).

Equation (37), which describes the effect of \( e \) on \( Q \) if \( q^* \) is kept constant, is very similar to (86). The fact that in (86) the coefficient is smaller than \( \eta_{Qq} + \eta_{Qp} \) is due to the decreasing influence of \( e \) on \( q^* \).

3.17. Results for manufacturing

We now summarise these:

1. The differentials \( dQ \) and \( de \) have the opposite signs at every \( e > e_0 \). Equation (86) shows how \( dQ \) depends on \( de \).
2. The differentials \( dq^* \) and \( de \) have the opposite signs at every \( e > e_0 \).
3. The differentials \( dq \) and \( de \) have the same signs at every \( e > e_0 \). Equations (80) and (81) show how \( dq \) depends on \( de \).
4. \( |dq/q| \) is smaller than \( |de/e| \).

3.18. Comment

The results inform us about what happens in the case of an increase or decrease in the exchange rate \( e \) within the range \( e > e_0 \). An increase is a devaluation and a decrease is an appreciation. In the case of a devaluation, the quantity \( (Q) \) of local manufactures falls and the price rises, but by a smaller percentage than \( e \). An appreciation has the opposite effect: the quantity \( (Q) \) rises and the price \( (q) \) falls, but by a smaller percentage than \( e \).

It is important for these results that local manufactures are not exported. Otherwise a decrease in \( q^* \) might stimulate exports to an extent that overcompensates for the fall in domestic demand for manufactures.

3.19. Effects on exports and the price of rural goods

Since \( b \) is positive, from (54) it follows that \( dX \) and \( dQ \) have opposite signs at every \( e > e_0 \). It follows from result (1) for manufacturing that \( dX \) and \( de \) have the same sign at every \( e > e_0 \). Since \( e^* \) is negative, (68) shows that \( dX \) and \( dr^* \) have opposite signs. Therefore \( dr^* \) and \( de \) have opposite signs at every \( e > e_0 \).
We now turn our attention to the relationship between $dr$ and $de$. With the help of (67) and (68), equation (70) yields:

$$\frac{dr}{r} = -\varepsilon^* \frac{R}{X} \frac{dQ}{Q} + \frac{de}{e}. \quad (87)$$

We insert the right-hand side of (86) for $dQ/Q$ and obtain

$$\frac{dr}{r} = \left( 1 - \varepsilon^* \frac{R}{X} \frac{\eta_{Qq} + \eta_{Qp}}{1 - \beta \eta_{Qq}} \right) \frac{de}{e}. \quad (88)$$

The differentials $dr$ and $de$ have the same sign at those values of $e$ at which the coefficient of $de/e$ is positive, and they have opposite signs where this coefficient is negative. The coefficient is positive if and only if we have

$$1 = \beta \eta_{Qq} - \varepsilon^* \frac{R}{X} (\eta_{Qq} + \eta_{Qp}) > 0. \quad (89)$$

In view of (76), this is equivalent to

$$\varepsilon^* \frac{R}{X} (\alpha \eta_{Qq} + \eta_{Qp}) < 1. \quad (90)$$

Inequality (90) is a necessary and sufficient condition for $dr$ and $de$ to have the same signs. Similarly

$$\varepsilon^* \frac{R}{X} (\alpha \eta_{Qq} + \eta_{Qp}) > 1 \quad (91)$$

is a necessary and sufficient condition for $dr$ and $de$ to have the opposite sign.

### 3.20. Sufficient conditions for $dr$ and $de$ to have the same sign

Since $\varepsilon^*$ is negative and $\eta_{Qp}$ is positive, one gets a stronger inequality if $\eta_{Qp}$ is omitted from (90). Therefore

$$\varepsilon^* \alpha \eta_{Qq} < 1 \quad (92)$$

is a sufficient condition for $dr$ and $de$ having the same sign. The quasi-elasticity $\eta_{Qq}$ is simply $\varepsilon_{Qq}$ multiplied by $Q_c/Q$. Therefore (92) can be rewritten as follows:

$$\frac{R}{X} \frac{Q_c}{Q} \varepsilon \varepsilon_{Qq} < 1. \quad (93)$$

### 3.21. Results for rural goods

1. The differentials $dX$ and $de$ have the same signs at every $e > e_0$.
2. The differentials $dr^*$ and $de$ have the opposite signs at every $e > e_0$.
3. Inequality (90) is necessary and sufficient and inequality (93) is sufficient for \( dr \) and \( de \) to have the same sign. Inequality (91) is necessary and sufficient for \( dr \) and \( de \) to have opposite signs.

3.22. Discussion of the sufficient condition for \( dr \) and \( de \) to have the same sign

The left-hand side of (93) is a product of five factors. The quotient \( R_Q/X \) measures the importance of rural goods inputs into manufacturing relative to exports. We refer to it as the home use ratio of rural goods, in brief the home use ratio. The quotient \( Q_C/Q \) is the fraction of local manufactures consumed. We call it the manufacturing consumption rate. The import share \( \zeta \), defined by (63), is the share of imports in the variable costs of manufacturing. The remaining two factors, the inverse demand elasticity of exports, \( e^{*}_C \), and the own price elasticity of manufactured consumer goods, \( e_{Qq} \), are both negative. Small absolute values of all five factors are favourable to satisfy (93).

The manufacturing consumption rate and the import share in the variable costs of manufacturing are smaller than one by definition. Nothing general can be said about the other three factors. However, in the case of Australia in the mid 1970s, the background of our modelling, the relevant input–out parameters can be computed from the *Australian National Accounts Input-Output Tables for 1974–1975* (Australian Bureau of Statistics, table 11, pp. 294–295) in conjunction with Pope (1986; table 4.4, p. 231, table 4.5, p. 232, table 4.8, p. 236, table A4.2.3, p. 257, table A4.3.1, pp. 259–277 and table 6.3, pp. 347–348). The data show the following picture:

\[
\frac{R_Q}{X} = 0.2 \\
\frac{Q_C}{Q} = 0.41 \\
\zeta = 0.51
\]

It is hard to identify the export elasticity of demand for Australia’s rural exports. Estimates range from \(-40\) (the parameter initially adopted for all rural exports in Australia’s computable general equilibrium model Orani, Dixon et al., 1977) down to \(-0.4\) (the lower end of average econometric estimates reported for some products in Gordon, 1986). While \(-40\) is probably overstating the absolute elasticity of Australia’s aggregate rural exports, it seems to be plausible that it is nevertheless quite high, above 1 but less than 40. Australia’s absolute aggregate export elasticity has been estimated as 4 (Powell and Murphy, 1997, p. 205). This would make for an absolute value of the inverse export elasticity \( e^*_C \) of one-quarter. If this is the case, given the 1970s parameter values, provided only that the absolute value of \( e_{Qq} \) was less than 100, this would still be compatible with (93). It therefore seems safe to conclude that during the period covered by the regression reported in the introduction, (93) was satisfied. During other periods, this may not be the case.

The five factors on the left-hand side of (93) are all functions of \( e \). Even during the 1970s, therefore, there may have been a subrange of \( e > e_0 \), in which
(91) holds, the necessary and sufficient condition for \(dr\) and \(de\) to have opposite signs. Drastic changes in the exchange rate might have brought Australia into such a range.

Consider an economy with a trade structure similar to that of Australia that has a great deal of power in its export market. For such an economy a decrease in \(e\) (i.e. an appreciation, which increases \(Q\) and thereby \(X\), may push \(r^*\) upwards so much that the influence of \(e\) on \(r\) is overcompensated, and \(r\) rises. In this case \(dr\) and \(de\) would have opposite signs.

It is maybe worthwhile pointing out that the directions of the effects of \(e\) on the quantity \(Q\) and the price \(q\) of manufactures do not depend on whether the differentials of the price of rural goods and the exchange rate, \(dr\) and \(de\), do or do not have the same sign. As far as results 1, 2, 3 and 4 for the manufacturing sector are concerned, this does not matter.

### 3.23. Effects on the price and quantity of imported goods

As we have already shown in (73), there is no difference between the relative differentials for the retail price of imports \(dp/p\) and for the exchange rate and \(de/e\). Therefore \(dp\) and \(de\) have the same sign at every \(e > e_0\). In the following we shall also look at consumption demand for imported goods defined in (7), even though \(P_C\) is not a variable in the condensed system. Since \(s\) is not influenced by the exchange rate, we have

\[
\frac{dP_C}{P} = \eta_{PR_D} \frac{dp}{P} + \eta_{PQ} \frac{dq}{q}.
\]  

(94)

Equation (64) can also be written as follows

\[
\frac{dP}{P} = \frac{P_Q dQ}{P Q} + \frac{dP_C}{P}.
\]  

(95)

Since \(dp/p\) is nothing other than \(de/e\), it follows from (80) and (94) that the following is true:

\[
\frac{dP_C}{P} = (\eta_{PR_D} + \gamma \eta_{PR_H}) \frac{de}{e}.
\]  

(96)

Inequality (82) shows that \(\gamma\) is positive and smaller than 1. Therefore the non-inferiority and gross substitutability assumptions permit the conclusion that the coefficient of \(de/e\) in (96) is negative. Consequently and \(de\) have opposite signs at every \(e > e_0\). Result 1 on manufacturing shows that \(dQ\) and \(de\) also have opposite signs at every \(e > e_0\). We can conclude that at every \(e > e_0\), the differentials of the quantity of imports and the exchange rate, \(dP\) and \(de\), have opposite signs.

### 3.24. Results for imported goods

1. The differentials \(dp\) and \(de\) have the same sign at every \(e > e_0\).
2. The differentials \(dP_C\) and \(de\) have opposite signs at every \(e > e_0\).
3. The differentials \(dP\) and \(de\) have opposite signs at every \(e > e_0\).
3.25. Effects on the quantity of services

In our model the price s of services, is not influenced by the exchange rate. In view of (73) and (80), equation (66), the equation for \( dS/S \) enables the following conclusion

\[
\frac{dS}{S} = (\eta_{Sp} + \gamma \eta_{Sq}) \frac{de}{e}.
\]

(97)

Since \( \gamma \) is positive, it follows from the gross substitutability assumption that the coefficient of \( de/e \) in (97) is positive. Therefore \( dS \) and \( de \) have the same sign at every \( e > e_0 \).

3.26. Result for services

The differentials \( dS \) and \( de \) have the same sign at every \( e > e_0 \).

3.27. Effects on the trade balance

The trade balance was not included in the list of variables for the full system, since it is not important for our main conclusions. It is nevertheless of interest to examine how it responds to changes in the exchange rate. We must distinguish between the trade balance in foreign money, denoted \( H^* \), and the trade balance in home currency, denoted \( H \):

\[
H^* = Xr^* - Pp^*
\]

(98)

\[
H = eH^* = Xr - Pp_0.
\]

(99)

The results that we wish to derive require the following additional assumption with respect to the inverse export elasticity:

\[
e^* > -1.
\]

(100)

This means that the export elasticity is smaller than \(-1\), or in other words that exports are elastic with respect to the foreign currency price of rural goods \( r^* \). For Australia, the background to our modelling effort, this seems to be the case, as discussed in section 3.22.

It is clear that \( H \) and \( H^* \) are differentiable. We can extend the full system by adding these variables and meaningfully form the differentials \( dH^* \) and \( dH \). We first look at \( dH^* \)

\[
dH^* = Xdr^* + r^*dX - p^*dP.
\]

(101)

In view of (68) this yields

\[
dH^* = (e^* + 1)r^*dX - p^*dP.
\]

(102)
From Result 1 for rural goods, \(dX\) has the same sign as \(de\) at every \(e > e_0\). In conjunction with our additional assumption \(e^* > -1\), this has the consequence that the first term in (102) has the same sign as \(de\) at every \(e > e_0\). From Result 3 for imported goods, \(dP\) and \(de\) have opposite signs for every \(e > e_0\). It follows that \(dH^*\) and \(de\) have the same sign for every \(e > e_0\).

We now turn our attention to the trade balance in home currency. We have
\[
dH = edH^* + H^*de. \tag{103}
\]

It follows from the result for \(dH^*\) that \(dH\) has the same sign as \(de\) at every \(e > e_0\) for which \(H^*\) is positive. For Australia, during the 1970s period under consideration, the trade balance in foreign (and local) currency was positive. However, in the case of a country with a negative trade balance in foreign money, a devaluation could worsen the trade balance in the home currency.

It is also possible that the trade balance is negative regardless of what the exchange rate is within this range. Let us assume that this is not the case and that in principle balanced trade can be achieved. More precisely, let us make the following assumption:

Balanced trade possibility assumption: an exchange rate \(e^*\) with \(e^* > e_0\) exists at which \(H^*\) is zero.

If the balanced trade possibility assumption is satisfied, then it is always possible to achieve a non-negative trade balance \(H^*\) by a sufficiently large devaluation. If \(H^*\) becomes non-negative, \(H\) becomes non-negative too. Under the balanced trade possibility assumption, a devaluation that fails to improve a negative home currency trade balance is simply not large enough to achieve this effect.

### 3.28. Results for the trade balance

1. The differentials \(dH^*\) and \(de\) have the same sign at every \(e > e_0\).
2. For every \(e > e_0\) where \(H^*\) is non-negative, \(dH\) and \(de\) have the same sign.
3. If the balanced trade possibility assumption is satisfied and \(H^*\) is negative at \(e > e_0\), then a sufficiently large increase in \(e\) will result in a non-negative value for \(H\).

### 3.29. Import penetration

We use the term import penetration for the ratio
\[
z = \frac{P}{Q}. \tag{104}
\]

In the same way as in our analysis of \(H\) and \(H^*\), we can augment the model with the additional variable \(z\), and we can look at the differential \(dz\) of \(z\).

It is usually expected and empirically observed, including in the case of Australia in the 1970s and 1980s (see figure 1) that a devaluation decreases and an appreciation increases import penetration. In the framework of our model,
this means that \( dz \) and \( de \) have opposite signs. We investigate the conditions under which this is the case.

We have

\[
dz = \frac{QdP - PdQ}{Q^2}
\]  

(105)

or equivalently

\[
\frac{dz}{z} = \frac{dP}{P} - \frac{dQ}{Q}
\]  

(106)

In view of (95), this can be rewritten as follows

\[
\frac{dz}{z} = \frac{dPC}{P} - \left(1 - \frac{PQ}{P} \right) \frac{dQ}{Q}
\]  

(107)

Equation (96) describes the first term on the right-hand side as a function of \( de/e \). It will be useful to look more closely at the coefficient of \( de/e \) in (96). From the definition of \( \gamma \) in (81), we have

\[
\eta_{Pp} + \gamma \eta_{Pq} = \frac{(1 - \beta \eta_{Qq}) \eta_{Pp} + (1 + \beta \eta_{Qq}) \eta_{Pq}}{1 - \beta \eta_{Qq}}.
\]  

(108)

Define

\[
\mu = \eta_{Pp} \eta_{Qq} - \eta_{Pq} \eta_{Qp}
\]  

(109)

With this notation (108) can be rewritten as follows

\[
\eta_{Pp} + \gamma \eta_{Pq} = \frac{\eta_{Pp} + \eta_{Pq} - \beta \mu}{1 - \beta \eta_{Qq}}
\]  

(110)

In view of gross substitutability and non-inferiority \( \eta_{Pq} \) is smaller than \(|\eta_{Pp}|\) and \( \eta_{Qp} \) is smaller than \(|\eta_{Qq}|\). Therefore \( \mu \) is positive. In view of (86), (96) and (110), equation (107) can now be rewritten as follows:

\[
\frac{dz}{z} = \frac{1}{1 - \beta \eta_{Qq}} \left[ \eta_{Pp} + \eta_{Pq} - \beta \mu - \left(1 - \frac{PQ}{P} \right) (\eta_{Qp} + \eta_{Qq}) \right] \frac{de}{e}.
\]  

(111)

Therefore the inequality

\[
\eta_{Pp} + \eta_{Pq} - \beta \mu < \left(1 - \frac{PQ}{P} \right) (\eta_{Qp} + \eta_{Qq})
\]  

(112)

is a necessary and sufficient condition for \( dz \) and \( de \), the differentials of import penetration and the exchange rate, to have opposite signs at an exchange rate \( e > e_0 \).

3.30.  **Sufficient conditions for \( dz \) and \( de \) to have opposite signs**

If the term \(-\beta \mu\) is omitted from (112), one obtains a tighter inequality, which is a sufficient condition for \( dz \) and \( de \) to have opposite signs. The inequality
obtained in this way, expressed in terms of elasticities rather than quasi-elasticities, is as follows:

\[
\frac{P_C}{P} (\varepsilon_{Pp} + \varepsilon_{Pq}) < \frac{Q_C}{Q} \left( 1 - \frac{P_Q}{P} \right) (\varepsilon_{Qp} + \varepsilon_{Qq}).
\]

(113)

In view of non-inferiority and gross substitutability \((\varepsilon_{Pp} + \varepsilon_{Pq})\) and \((\varepsilon_{Qp} + \varepsilon_{Qq})\) are both negative. Therefore the following two inequalities together imply (113):

\[
\varepsilon_{Pp} + \varepsilon_{Pq} < \varepsilon_{Qp} + \varepsilon_{Qq}
\]

(114)

and

\[
\frac{P_C}{P} \geq \frac{Q_C}{Q} \left( 1 - \frac{P_Q}{P} \right).
\]

(115)

The two differentials \(dz\) and \(de\) have opposite signs if (114) and (115) are both satisfied. The elasticity condition can be interpreted as follows. Suppose that \(p\) and \(q\) are increased or decreased by the same percentage while \(s\) is kept constant. Thereafter these prices are \(\lambda p\) and \(\lambda q\) for some \(\lambda > 0\). In order to examine the consequences of a sufficiently small price change of this kind, we look at the derivatives of consumption demand for imported goods and manufactures with respect to \(\lambda\) at \(\lambda = 1\).

\[
\frac{\partial}{\partial \lambda} D_M(\lambda p, \lambda q, s)|_{\lambda=1} = p D_{Mp} + q D_{Mq}
\]

(116)

for \(M = P, Q\). From (7), (8) and section 2.2.7, this is equivalent to

\[
\frac{\partial}{\partial \lambda} D_M(\lambda p, \lambda q, s)|_{\lambda=1} = M_C(\varepsilon_{Mp} + \varepsilon_{Mq})
\]

(117)

for \(M = P, Q\). Equation (117) means that a price increase in \(p\) and \(q\) by the same sufficiently small fraction \(\delta\) leads to a decrease in \(M_C\) by the fraction \(\delta|\varepsilon_{Mp} + \varepsilon_{Mq}|\). Condition (114) has the interpretation that \(P_C\) responds proportionately more strongly to price changes than does \(Q_C\).

The loss in real income connected with an increase in the prices of imported goods and manufactures by the same percentage may hit consumption demand for imported goods much more than for manufactures, since imported consumption goods are often luxuries. Therefore (114) is not an unreasonable assumption. It is plausible for Australia where estimates of the income elasticity for consumer imports are between 1.5 and 2.0 (Bullock et al., 1993, pp. 102–106; Dwyer and Kent, 1993, p. 17, table 2 and pp. 26–27, table A3.1). In contrast, the income elasticity for local manufactures

seems to be considerably lower, in the vicinity of 1.1 (Table 1, section 1.4.1 of this paper).\textsuperscript{11}

However, (115) does not lend itself to a defence by plausibility arguments. Whether this condition is a reasonable assumption must be judged in the light of empirical evidence. In the case of Australia, from the \textit{Australian National Accounts Input-Output Tables 1974–1975} (Australian Bureau of Statistics, table 11, pp. 294–295) and related statistical investigations (Pope, 1987, table 4.4 p. 231, table A4.3.3, p. 280) suggest that it was satisfied in the 1970s. For the years 1974–1975, the data show the following picture:

\[
\frac{P_C}{P} = 0.24 \\
\frac{Q_C}{Q} = 0.41 \\
\frac{P_Q}{P} = 0.49.
\]

This yields 0.24 for the left-hand side and 0.21 for the right-hand side of (115). With these numbers, the condition is satisfied, albeit not by a wide margin.

The model suggests that for countries with a trade structure like that of Australia, one cannot automatically assume that a devaluation diminishes import penetration. Slightly different numbers (e.g. 0.5 for both $Q_C/Q$ and $P_Q/P$ together with 0.2 for $P_C/P$) would violate (115). However, the sufficient condition (113) may still be satisfied if (114) holds by a wide enough margin.

3.31. \textit{Results for import penetration}

1. Inequality (112) is necessary and sufficient for the differentials $dz$ and $de$ to have opposite signs at an exchange rate $e > e_0$.

2. Inequality (113) is a sufficient condition for the differentials $dz$ and $de$ to have opposite signs and the inequalities (114) and (115) are jointly sufficient for (113).

\textsuperscript{11}This latter is an estimate of the response to real gross national expenditure of aggregate manufacturing (i.e. inclusive of locally manufactured intermediate and capital goods) not just locally manufactured consumer goods. However, for alternative activity variables and for all three classes of imports, consumer, intermediate and capital goods, the elasticities were fairly similar. It may likewise be the case that for local manufactures, that the elasticities for the analogous classes are likewise similar to each other. In this case the real gross national expenditure elasticity for aggregate manufactures is a good proxy for the real gross national expenditure elasticity of manufactured consumer goods. Note also that the import point estimates elasticities are (like that of Pope in table 1 above) reasonably accurate insofar as their estimated standard errors were in excess of 1/10 the estimated elasticity. These import elasticities by class are long run estimates, whereas for our model, the short-to-medium run income elasticities are pertinent, and these might be expected to be even higher (Bullock \textit{et al.}, 1993, figure 9). However, at least at the aggregate level, estimates of short run income elasticities for imports are approximately the same as those for the long run (Wilkinson, 1992).
4. CONCLUDING REMARKS

We have presented a model of an open economy with some special features. Local manufactures are not exported but only used at home. Exports are rural goods exclusively. Local manufacturing uses imports and exportables as variable inputs. The costs of these material inputs determine the price of local manufactures. Some imports are consumption goods that compete with local manufactures but not as perfect substitutes. For a more complete and more detailed description of the model, see sections 1.5 and 2.

The model portrays an economy similar to that of Australia. However, it seems to be a plausible conjecture that the assumptions of the model are also adequate as an idealised description of some developing countries, even if the lack of sufficiently elaborate statistics may make it difficult to judge the extent to which this is true in a particular case.

Standard texts on international trade theory suggest that devaluations are beneficial and appreciations are damaging to local manufacturing (for references, see section 1.1). A devaluation is thought of as increasing the home currency price of imports by a higher percentage than that of local manufactures. Thereby the competitiveness of local manufactures is strengthened. This import competition effect is present in our model, but it is dominated by an input cost effect of a devaluation: the rise in the price of imports and exportables increases the cost of material inputs and thereby the price of local manufactures. The price increase results in a decrease in the demand for local manufactures. Therefore in our model a devaluation decreases the production of local manufactures whereas an appreciation increases it.

As we have seen with the help of Australian data, it is not only a theoretical possibility, but an empirical phenomenon that at least in this case local manufacturing is hurt by devaluations and helped by appreciations. One can expect that the same holds also for other economies with a similar structure.

We do not want to exaggerate the policy implications of our model, but we think that it may be advisable for an organisation like the International Monetary Fund to be aware that the recommendation of a devaluation may be counterproductive. In this respect our model may be useful as a guide to the features of the situation that need to be examined. If exports are predominantly rural goods, and if imports and exportables have an important role as inputs into local manufacturing, then one should seriously consider the possibility that an input cost effect dominates the consequences of an exchange rate adjustment.

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