Increasing Returns, Financial Capital Mobility and Real Exchange Rate Dynamics*

Steven Pennings[1] and Rod Tyers[2]

JEL Codes: F21, F31, F32 F41, F43

Abstract

The 1990s appreciation of the US$ has been blamed on the "irrational exuberance" of investors in the US IT boom. A core of these investors appeared to believe that technology-related productivity growth (due, in part, to knowledge spill-over externalities) would raise the relative US rate of return over a sustained period. This paper introduces a two country, dynamic general equilibrium model with international financial capital mobility and trade to investigate the conditions under which a single technology shock could cause such a sustained change in capital flows. We find that a once-off productivity shock, whether in the presence of (small-medium) externalities or not, leads to capital inflow and a real appreciation in the short term but is followed in the long term by a stabilisation of the capital account and a net depreciation of the real exchange rate. For a single shock to trigger long-term growth in relative capital returns appears to require unrealistically large externalities. The presence of adaptive expectations can lead to persistence and cyclical behaviour in the real exchange rate and current account.

1 Reserve Bank of Australia, Economic Group, GPO Box 3947, SYDNEY NSW 2001, penningss at the domain rba.gov.au

2 Australian National University, College of Business and Economics, HW Arndt Building, Australian National University, ACT 0200, rod.tyers at the domain anu.edu.au

* This paper stems from research undertaken when Steven Pennings was at the Australian National University. Thanks are due to Jill Harrison, Centre of Policy Studies, Monash University, for assistance with the modelling software used.

Increasing Returns, Financial Capital Mobility and Real Exchange Rate Dynamics*

1. Introduction

The late 1990s saw an appreciation of the US Dollar against the Euro and Australian Dollar of around 50 per cent (Figure 1). Then over 2002-03, it lost all of the ground it had gained over the previous seven years.[1] The late 1990s coincided with the US information technology (IT) boom during which global financial markets funded high levels of US investment,[2] apparently based on the expectation that US productivity growth, and hence the relative rate of return on US capital, would be permanently higher as a result.[3] In the language of the day, the "internet revolution" was seen as creating a "new economy", where technological progress could drive the economy faster without inflationary pressures (Oliner and Sichel 2000, Bailey 2002). The particular gains to the US were seen as stemming not only from applications of the new technology, which was taken up almost as quickly in many countries (including Australia), but also from the returns to the US firms that created the associated hardware and software.[4]

The US slowdown of 2001-2002 and the associated stock market crash put an end to these expectations. Yet, as Figure 2 shows, in the late 1990s US labour productivity growth averaged 2.5 percent: almost double the average of the previous twenty years. There has been much debate about the reasons for this acceleration, however. Gordon (2000) argued, at least

[1] Low inflation globally meant that changes in nominal exchange rates translated directly into changes in real exchange rates (Figure 1).

[2] "Growth in real equipment investment over the period 1992-98 [in the US] averaged 11.2 per cent per year, exceeding all other seven year intervals in the post World War II Era" (Tevlin and Whelan, 2003, p1). Over the 1990s, net purchases of US assets by foreigners grew from US$141bn to US$1016bn, with over 80 per cent of the increase being due to greater direct investment, and purchases of US stocks and bonds (Mann 2002).

[3] "It is frequently asserted that the reason the US dollar is rising is because everyone wants to buy US equities, particularly tech stocks, because that is where the high returns are." *Macfarlane (2000)*.

[4] "It [the 'new economy' theory for the depreciation of the Australian dollar against the US dollar] essentially says that equity investment (direct and portfolio) is less attracted to Australia than formerly since we are viewed as an 'old economy' because we do not have a big enough exposure to the new growth areas, particularly the information and communications technology sector (ICT). The contrast is drawn between the United States, which is seen as the 'new economy', and other countries, including Australia. Proponents of the 'new economy' view tend to concentrate on the production of the ICT sector, and give Australia low marks for not having more resources in this area." *Macfarlane (2000)*

initially, that much of the increase was cyclical, while Oliner and Sichel (2000) attributed half of the higher productivity growth to capital deepening as firms invested in IT. They ascribe the other half to faster total factor productivity growth, of which 40% was due to efficiency gains in computer production. This means that around two thirds of labour productivity growth was IT related.[5] More recent research on the same productivity change confirms the once-off nature of the productivity shock, the associated once-off rise in the IT share of national investment and the marriage in that period of computers with communication technology (Gordon 2006, 2007; Jorgenson et al. 2007).[6]

There are several reasons why the initial advantage of the US in IT might have lead to faster long run growth relative to other countries. First, high-tech industries could exhibit learning-by-doing, as in Lucas (1988), and Baldwin and Krugman (1992). Second, technological spillovers may have allowed a sustained increase in *relative* US technical progress. At the regional level, Saxenian (1994) argues that spill-overs from the collaborative culture of Silicon Valley gave it an advantage over older research and development zones such as Route 128 in Boston.[7] Third, external economies associated with proximity to specialised labour markets and intermediate input suppliers encourage co-location, regionally and nationally (Krugman and Venables 1990 and Venables 1996). All of these factors suggest the presence of (internal or external) increasing returns in industries using or producing IT.

Suppose, for these reasons, that the "new economy" expectations were well founded, and the US economy had a unique (or comparatively large) IT productivity externality, conferring on its IT industry increasing returns to scale. This paper examines this situation in

[5] Other studies, as discussed in Bailey (2002), also suggest information technology made a substantial contribution to productivity growth.
[6] In the later works, Gordon and Jorgenson et al. recognise that the effect of technical change may be understated if capital deepening is a result of falling computer prices, as had been suggested by Barro and Sala-i-Martin (2004) and Tevlin and Whelan (2003). Controversy continues as to the extent of the post-2000 productivity slowdown and prospects for continued US productivity growth.
[7] The argument of very localized externalities is supported by a range of empirical papers, such as Acs *et al* (1994), Jaffe *et al* (1993) and Bottazzi and Peri (2003).

the context of a generic two-country global model, focussing on the effects of a technology shock on financial capital flows into the focus region and its real exchange rate. In particular, it addresses the conditions under which the capital flows into the region could cause an agglomeration of the IT industry in that region. Opposing forces include a rising local real wage and the cost of local investment goods. At issue is whether these are sufficient to bring the global economy to a new stable steady state.

The paper is organised as follows. Section 2 reviews the relevant literature and Section 3 describes the numerical model adopted. Section 4 presents the simulated effects of a once-off IT-related productivity shock without externalities and with myopic financial investors. Externalities are then added in Section 5. Section 6 analyses effects of adaptive expectations and Section 7 concludes.

2. Prior Research

According to the "economic geography" literature, a combination of increasing returns and transportation costs can lead to an agglomeration of industry in one region – a polar separation between an "industrial core" and an "agricultural periphery". In models with mobile factors (Krugman 1991), the mechanism is "demand-linked circular causality", where the movement of a firm to the larger region raises the marginal product of mobile factors, causing a co-movement to the same region. This creates an even larger market, which then attracts more firms. If factors are not mobile, as in Krugman and Venables (1990), then agglomeration is never complete, because a higher wage in the destination region eventually prevents the relocation of firms.[8]

Baldwin (1998) adds internationally immobile (firm specific) capital. Then, if there is an increase in profitability in country A, this increases incomes in A, creating a larger market.

[8] In Venables (1996), final-goods firms will move markets to be closer to firms producing intermediate inputs, then intermediate goods firms will follow the final goods firms.

Firms move from country B to A, where the higher savings required to finance the firm-specific capital stem from higher rates of return on capital in country A. This establishes a virtuous circle for A, where workers move from the agricultural industry to the manufacturing industry (with the reverse happening in country B), leading to the manufacturing core – agricultural periphery result of Krugman's model with mobile labour.

The important point to note is that it is *the immobility of the firm-specific physical capital that drives the agglomeration*. If capital were mobile, then higher returns in A would lead to investment in A by both A and B. In turn, this would lead to higher incomes in both A and B, leaving no incentive for firms to move from B to A to access the larger market. Thus, international capital mobility stops expenditure shifting and breaks the demand linked circular causality that is essential for agglomeration. For this reason, we do not follow Baldwin (1998) or similar models of the economic geography type.[9]

Grossman and Helpman (1991) present an international version of Romer's (1990) expanding product variety endogenous growth model. There are two countries, both producing a "traditional" good and a "high-tech" differentiated product using homogenous labour as their only factor. New products are discovered by an R&D sector, which uses labour and knowledge (from past inventions) as its only inputs. The important feature of this model is that knowledge generated by innovation is a *national* (rather than international) public good – so larger countries or those with larger initial stocks of knowledge are naturally advantaged. In this setting Grossman and Helpman find that the country that initially has the larger stock of knowledge – which can be thought of as being generated from a larger initial R&D industry – tends to dominate the production of the high-tech good in the long term. The second country increasingly falls behind, unless it is much larger, and so is able to gain knowledge at a fast pace (making use of Romer's "large scale effect"). In the context of the

[9] This is also because we focus on the macroeconomic implications of increasing returns, not its microeconomic foundations.

internet boom of the late 1990s, one can think of the US gaining the initial knowledge advantage from their greater use of the internet in its first few years of invention. This model would then predict that the US could use that extra knowledge to become more productive in R&D (consistent with the "new economy" thesis), and eventually dominate the global high-tech industry. Unfortunately, Grossman and Helpman (1991) do not include physical capital, so we do not know how the regional distributions of savings and investment are affected.

Lucas (1988) emphasises (human) capital accumulation through learning-by-doing, where high-tech goods generate faster accumulation than low-tech goods. The country that initially specialises in the high tech good grows faster, but faces a decreasing terms of trade. Applying this idea to the late 1990s, if the US were able to specialise in high-tech goods through its initial advantage, its overall growth would have been faster in the long term. In a model with physical capital as the third factor, this would lead to higher returns to capital in the US, leading to an inflow of foreign capital. As the price of high tech goods falls in the long term due to fast human capital accumulation, the real exchange rate would depreciate, because such goods form an ever larger share of US GDP. Although the model adopted in this paper offers a simpler productivity growth mechanism, large externalities yield, in common with the Lucas model, a depreciating real exchange rate and faster long term capital accumulation in the focus region.

Real exchange rates are approached from two perspectives in the literature. First, in models that incorporate nominal rigidities (such as Mundell 1963, Fleming 1962 and Dornbusch 1976) real exchange rates follow nominal exchange rates in the short-term (and hence depart from PPP), but in the long term they tend towards PPP as prices become more flexible (Devereux 1997). The alternative view, which motivates our approach, is that real exchange rates are driven by real disturbances such as productivity and shocks to financial flows due to changes in savings, investment and fiscal policy (Stockman 1988, Lucas 1982, Tyers and Golley 2007)..

3. The Model

Consider a world with two initially identical regions, Home (H) and Foreign (F), in which both produce and freely trade two goods (*X* and *Y*).[10] There are three primary factors: labour (*L*), capital (*K*) and land (*N*). *X* is low-tech and uses labour and land. *Y* uses labour and capital and it may have a positive production externality in both regions. Saving rates from regional income are fixed and both collective households maintain asset portfolios that include foreign capital. There is no population growth, time is discrete and the two regions are initially in a steady state. In our experiments, this steady state is disturbed by a 10% once–off productivity shock to the *Y* industry in the home economy. Impulse responses are then calculated for the capital stocks, real exchange rates, and real GNP levels, with and without a positive externality in the Home region.

The technologies in both sectors are Cobb-Douglas:

$$(1) \qquad X_i = AL_{X,i}^{\;1/2} N_{X,i}^{\;1/2}, \quad Y_{i,t} = (aK_{i,t}^{\;\psi}) L_{Y,i,t}^{\;1/2} K_{i,t}^{\;1/2}, \quad \forall i \in H, F$$

The positive externality or scale economy arises if $\psi > 0$, representing greater localised technological spillovers (Grossman and Helpman 1991) or learning-by-doing (Lucas 1988). Since the scale economy is external to the firm, high-tech firms do not recognise the effect of greater capital use on their productivity. At any point in time, constant returns to scale is therefore perceived by firms and they price competitively.

[10] We do not include a non-traded good in this version of our model and hence we ignore the popular Balassa (1964) – Samuelson (1964) effect of productivity changes on real exchange rates. While the inclusion of a non-traded sector would have improved the model, it would require a substantial additional layer of complexity to deal with the allocation of old and new physical capital between the *Y* sector and the non-traded sector. In any case, the Balassa-Samuelson effect is found to be dominated by departures from the law of one price for tradable goods and these departures are captured in our model via product differentiation. Recent work by Tyers and Golley (2007) suggests the inclusion of a non-traded sector would make real appreciations due to productivity surges more persistent than is indicated by the model used here but it would offer no qualitative change in the results.

Since both goods are traded, departures from PPP require failure of the law of one price for tradable goods. This is justified not only by the widespread observation of departures from PPP[11] but also by pervasive intra-industry trade. The most widely used approach to this is to assume product differentiation by country of origin, otherwise known as Armington (1969) differentiation.[12] Specifically, each region's collective household has separable utility in generic goods and region-specific varieties. Region *i*'s Cobb-Douglas utility in consumption of generic *X* and *Y*, $\hat{C}_{X,i}$ and $\hat{C}_{Y,i}$, is first maximised.

$$(2) \qquad \max_{\hat{C}_{X,i},\hat{C}_{Y,i}} U_i = \hat{C}_{X,i}^{\gamma}\hat{C}_{Y,i}^{1-\gamma} \text{ , subject to } \left(1-s_i\right)GNP_i = \hat{P}_{X,i}\hat{C}_{X,i} + \hat{P}_{Y,i}\hat{C}_{Y,i}, \quad \forall i \in H,F ,$$

where s_i is the regional saving rate. Then, accounting for differences in the prices of the home and foreign varieties, the cost of acquiring these generic volumes is minimised. The problem for *X* consumption is:

$$(3) \qquad \min_{C_{X,H,i},C_{X,F,i}} p_{X,H}C_{X,H,i} + p_{X,F}C_{X,F,i}\text{, subject to}$$

$$\hat{C}_{X,i} = \left(\phi_{X,H,i}C_{X,H,i}^{-\rho_C} + \phi_{X,F,i}C_{X,F,i}^{-\rho_C}\right)^{-\frac{1}{\rho_C}}, \quad \forall i \in H,F ,$$

where the elasticity of substitution between foreign and home varieties is $\sigma_C = 1/\left(1-\rho_C\right)$. Marshallian demands for each variety in each region follow from this, along with regional generic price indices; that for *X* taking the form:

$$(4) \qquad \hat{P}_{X,i} = \left(\phi_{X,H,i}^{-\sigma_C}p_{X,H}^{1-\sigma_C} + \phi_{X,F,i}^{-\sigma_C}p_{X,F}^{1-\sigma_C}\right)^{-\frac{1}{1-\sigma_C}}, \quad \forall i \in H,F$$

It follows that each collective household always consumes at least some of all four goods (X_H, X_F, Y_H and Y_F) and hence low productivity and a high price in one region does not preclude exports to the other.

[11] The significance of departures from the law of one price for tradable goods is demonstrated empirically by Engel (1993), Engel and Rogers (2001), Crucini et al. (2005) and Bergin et al. (2006).

[12] Following the work of Dixon et al. (1982) Armington preferences became the international standard. Differentiation at the level of the firm has enjoyed a recent resurgence, following Ghironi and Melitz (2005). In their study, however, firm heterogeneity endogenises productivity in a way that is unnecessary here.

Investment in each region is financed by the issue of (real) bonds, which are available for sale at home and abroad. Bonds from the two regions are imperfect substitutes. Initially, there is no home-bias in asset portfolios in either region, so the initial portfolios are split 50-50 between bonds issued in each region. In any year the collective household of each region *i* allocates new saving, $S_i = s_i GNP_i$, between the bonds of each region, *j*, to maximise a constant elasticity of substitution (CES) "utility" function in their expected incremental portfolio returns.

(5) $$\max_{B_{i,H}, B_{i,F}} \left[\alpha_{i,H} (r_H^e B_{i,H})^{-\rho_B} + \alpha_{i,F} (r_F^e B_{i,F})^{-\rho_B} \right]^{-\frac{1}{\rho_B}}$$

subject to $S_i = s_i GNP_i = B_{i,H} + B_{i,F}, \quad \forall i \in H, F$,

where the parameters α_{ij} govern the degree of incremental home bias and the elasticity of substitution between home and foreign bonds is $\sigma_B = 1/(1-\rho_B)$. The result is the addition of $B_{i,H}$ and $B_{i,F}$ to its bond portfolio. Collective households form expectations over bond yields either myopically, by presuming that future returns will equal those in the present period, or adaptively, projecting yields based on past trends.[13]

(6) $$r_i^e = \left\{ \begin{array}{l} r_{i,t} \\ r_{i,t-1} + \lambda\left(r_{i,t} - r_{i,t-1}\right) = \lambda r_{i,t} + \left(1-\lambda\right) r_{i,t-1}, 1 > \lambda > 0 \end{array} \right\}, \quad \forall i \in H, F \ .$$

This system allows imperfect financial capital mobility and differences in yields across countries without the explicit introduction of the practical causes of bond differentiation, namely credit risk, property rights enforcement, systemic (country) risk and fiscal stringency (monetary and nominal exchange rate stability). Moreover, it obviates the need for explicit representation of the smoothing forces on the investment side, which include implementation

[13] Forward-looking or model-consistent expectations are not assumed. Under bounded rationality, rules of the adaptive expectations type can be shown to be optimal (De Grauwe and Grimaldi 2004).

costs and gestation lags,[14] allowing an analytical focus on the role of the high-tech production externality.

The funds committed to investment in region *i* finance new purchases of capital goods that add to the capital stock:

$$(7) \qquad K_i^t = \left(1-\delta_i\right) K_i^{t-1} + I_i , \quad I_i = \frac{B_{H,i} + B_{F,i}}{P_{K,i}}, \quad \forall i \in H,F \ .$$

These new capital goods are constructed from *X* and *Y* by an "installation firm" that can only use domestic products, reflecting the importance of local installation costs.[15] The composition of capital goods is chosen to minimise cost, subject to a CES installation function:

$$(8) \qquad \min_{I_{X,i}, I_{Y,i}} \ P_{X,i} I_{X,i} + P_{Y,i} I_{Y,i} \ \text{subject to } I_i = \left(\beta_{X,i} I_{X,i}^{-\rho_I} + \beta_{Y,i} I_{Y,i}^{-\rho_I}\right)^{-\frac{1}{\rho_I}}, \quad \forall i \in H,F \ .$$

New capital goods are assumed to be intensive in high-tech *Y* so that $\beta_{Yi} > \beta_{Xi}$. From the solution to the investment installation problem emerges each region's capital goods price, $P_{K,i}$, as the familiar CES index of product prices in the manner of (Equation 4).

The yield on each region's bonds is then equal to the net rate of return on regional capital, or the value of the marginal product of capital in the production of high-tech *Y,* derived from (1) above, as a proportion of its capital goods price, net of depreciation.

$$(9) \qquad r_i = \frac{P_{Y,i} MP_K^i}{P_{K,i}} - \delta_i, \quad \forall i \in H,F \ .$$

The level of GNP in region *i* is the sum of rewards to factors owned by that region's collective household:

$$(10) \qquad GNP_i = n_i N_i + w_i W_i + P_{Y,H} MP_K^H K_{H,i} + P_{Y,F} MP_K^F K_{F,i}, \forall i \in H,F$$

---

[14] Gestation lags are, in any case, relatively short for IT related investments.

[15] Investment in structures is about half of total business investment, and it has only a small imported component. Without the region specificity an internationally funded "investment boom" would not affect the capital account directly because foreign firms could import their own machinery and equipment. Typically, growth models get around this problem because they only have one good, which is produced, consumed and used for investment.

where n_i is the land rental rate, w_i is the wage and $K_{i,H}$, $K_{i,F}$ reflect region i's ownership of home and foreign capital. Since there are no intermediate inputs or indirect taxes, GDP is simply the value of regional production (GDP at producers' prices):

(11) $$GDP_i = p_{X,i}X_i + p_{Y,i}Y_i, \quad \forall i \in H,F \ .$$

The GDP price level is constructed from output value weights, θ_{ji}. Thus, for region i:

(12) $$P_i^{GDP} = \theta_{X,i}p_{X,i} + \theta_{Y,i}p_{Y,i}, \quad \forall i \in H,F \ .$$

For welfare interpretations, a consumer price level is also defined, based on the expenditure function from (2), as:

(13) $$CPI_i = \hat{P}_{X,i}^{\gamma}\hat{P}_{Y,i}^{1-\gamma}, \quad \forall i \in H,F$$

The real exchange rate is the ratio of the cost of a product bundle in one region, to the cost of the corresponding bundle in the other, measured relative to a common global numeraire.[16] Appreciations are therefore indicated by increases and depreciations by decreases. Home's real exchange rate is then the ratio of its output-value weighted GDP price to a similarly weighted Foreign GDP price:

(14) $$e_H = \frac{P_H^{GDP}}{P_F^{GDP}} \ .$$

The model is calibrated to represent two initially identical large trading regions. The initial steady state and key parameters are detailed in Table 1. When a shock occurs to productivity at home several forces are set in train. These might be summarised as follows:

- *The investment demand effect* increases home prices relative to foreign prices, leading to a real appreciation, when the home country receives a larger share of world investment and hence is the recipient of an increased share of global financial flows. This effect is dominant in the short run.

[16] Since there is no money, all prices and values are calculated in terms of X_F. This is all that is required for the real exchange rate, but for variables with welfare implications there is subsequent deflation either by the region's GDP price or its CPI.

- *The product differentiation effect* decreases home prices relative to foreign prices, leading to a real depreciation, when the home industry produces more output. The home country must lower prices in order to sell the extra goods because products are differentiated. This effect drives real exchange rate movements in the long run.
- *The fixed factors effect* means that the marginal product of home capital (MP_K), and hence the rate of return on home bonds, falls with capital accumulation (at least so long as there is no externality in the home high-tech industry). This is because labour, which is fixed in local supply, cannot move into the home high-tech industry in the same quantities as capital. Moreover, since land (N) is also fixed, and employed only in the production of X, as labour moves into the Y industry its marginal product rises in the X industry, ensuring some retention. Factor prices are not equalised because labour is not mobile internationally, products are differentiated by region of origin and the productivity shock separates the technologies. This effect means that productivity shocks, at least with small production externalities, do not lead to agglomeration in the favoured region.
- *The capital price effect* complements the fixed factors effect in opposing the agglomeration of the high-tech (Y) industry in the home country. Even if the MP_K were to remain constant, returns would tend to fall with capital accumulation in the home country because its capital goods price rises relative to the price of the home variety of the high-tech product (Y). Capital accumulation increases Y production, which reduces the price of home Y relative to home X. As the price of capital goods is a function of both domestic X and Y prices, the price of new capital falls more slowly than the price of Y, leading to falling returns, which oppose agglomeration of the Y industry in the home country.

4. A Boost to Home Productivity with no Externalities (*ψ=0*)

The IT boom is represented by a once-off (but permanent) 10 per cent increase in total factor productivity in the home (but not in the foreign) *Y* industry.[17] The improved productivity in H drives up MP_K^H, raising the home relative-to-foreign expected bond yield (Figure 3). Financial investors are initially assumed to have myopic expectations. Whether their expectations are myopic or adaptive, however, this causes the home and foreign bond portfolios to be rebalanced in favour of home bonds, raising home investment at the expense of foreign.[18] In turn, this leads to relative accumulation of capital in H (Figure 4), and the associated net financial inflows necessitate a current account deficit (Figure 5). In F, falling relative returns lead to a fall in investment below its replacement level, and an absolute fall in its capital stock. Eventually, MP_K^H diminishes, increasing F's share of world investment, and some rebounding of F's capital stock. After 50 periods a new steady state is approached, with a larger capital stock in H, and a slightly reduced capital stock in F. The latter is due to a decline in global demand for its *Y* following increased competition from its now more productive counterpart in H.[19]

The higher level of productivity in H does not lead to an agglomeration of high-tech industry in the long run because of the *fixed factors effect*. H's fixed labour supply ensures that its accumulation of capital is greater than the flow of labour from *X* to *Y*. The tighter H labour market reduces MP_K^H, causing the H bond yield to fall through time. Initially, both the higher home wage and increased investment demand raise the relative price of H's *X*, raising the price of capital goods, and so contributing to the decline in the home bond yield. At the

[17] For example, online business-to-business inventory management and purchasing systems reduce costs and inventory overheads, but the gains are made when businesses move from conventional ordering systems, to online ordering systems. In this case, once the internet reached saturation point after a few years, no further productivity gains could be made.
[18] With adaptive expectations the effects are more persistent, as shown in Section 6.
[19] F responds to this by moving labour to the *X* goods sector, in which, following the productivity shock, it has a comparative advantage. In the new steady state, the output of foreign *X* rises by 1.1% while that of foreign *Y* falls by 2.3%.

same time, since investment is *Y* intensive, this demand tends to retard the long term fall in the price of newly abundant home *Y* and therefore the incentive to invest in the home *Y* industry.

The current account and the real exchange rate

Initially, higher productivity in the home country's *Y* sector raises the supply of home relative to foreign *Y*. Other things equal, product differentiation by country of origin ensures that the relative price of home *Y* falls (the *product differentiation effect*). But this effect is opposed in the short run by larger investment demand in H, which places upward pressure on the home prices of both *X* and *Y*, but particularly on that of *Y* (the *investment demand effect*). Initially, the investment demand effect dominates, and prices rise in the home country, leading to a real appreciation, as shown in Figure 5. With time, savings are redirected to investment in F, and investment goods demand falls in H, and rises in F. Prices in H fall without investment demand to prop them up, and the real exchange rate depreciates. In the long run, therefore, the *product differentiation effect* is dominant. Moreover, instead of approaching its initial level ($e=1$, or PPP), the real exchange rate reaches a new steady state below initial PPP. This is because H's permanently more productive *Y* industry must discount its products in order to sell them.

Welfare effects

H's higher *Y* productivity raises its *Y* output in both the short and long run. At least one country must therefore always be better off than before. From Figure 6 it is clear that, although F has lower GDP, both regions are net gainers in terms of real income.[20] This is because both regions share ownership of the newly advantaged home *Y* industry. These

[20] Our measure of welfare is GNP deflated by the (ideal) consumer price index in each country.

income gains accrue to capital owners in both regions, to home workers and to foreign land owners. Home land owners enjoy a higher *X* price but lower *X* employment, with the former dominating, so that home land rents also increase. Foreign workers suffer a wage decline in terms of the numeraire (*X* in F) but the foreign CPI also falls sufficiently to raise the real purchasing power of the foreign wage in the long term. Of course, since total factor productivity is higher at Home and its capital stock rises faster, home workers benefit more than foreign workers.

Sensitivity to elasticities of substitution

In general, the results are qualitatively similar when elasticities of substitution are changed. Consider, first, the effect of reducing the extent of product differentiation by country of origin. This compresses price movements as consumers switch between home and foreign goods more easily, reducing the strength of the *product differentiation effect*, leading to a smaller depreciation in the long run, and the *investment demand effect*, leading at a smaller appreciation in the short run.[21] These price movements lead to slower initial capital accumulation (and hence a smaller home current account deficit), but a larger home (and smaller foreign) capital stock in the long run. This leads to more equal real incomes in the short run, but more unequal real incomes in the long run.

An increase in the elasticity of substitution between regional bonds (σ_B) raises the sensitivity of savers to differences in yields and increases the international mobility of financial capital. Following the productivity shock, H attracts more capital initially and so has a larger current account deficit and a larger initial appreciation (increasing the size of the *investment demand* effect). The increased capital flow into H increases the speed of adjustment to a new steady state. Changes to the level of international capital mobility do not

[21] There is also a very small reduction of the capital price effect, which is relevant in the very long run.

affect the model in the long run because financial capital flows stabilise in the new steady state.

5. A productivity boom in the presence of a home externality (*ψ>0*)

Externalities in the US high-tech industry could have been a result of the unique industrial structure of such sub-regions as Silicon Valley, or they could be a feature of high-tech industries more generally. Saxenian (1994) supports the former, arguing that firms in Silicon Valley were typically smaller, more open and collaborative, and that this allowed skills and ideas to move through the Valley in a way that would not have been possible elsewhere.[22] This would have meant that human capital and knowledge were much closer to a public good in Silicon Valley than they were in other regions with larger, more secretive, more inward-looking firms. It is therefore assumed that that the externalities operated only in the home region.

The externality is incorporated into (Equation 1) by setting $\psi>0$ for the home country and retaining $\psi=0$ in the foreign country. The same productivity shock is then applied to the home high-tech industry.[23] The MP_K^H now depends on the size of the externality (ψ).[24] For small externalities ($0<\psi<0.5$), it is clear from (1) that diminishing MP_K^H is retained in H (the elasticity of home *Y* output to capital is less than unity). This means that the return to new units of capital falls over time as capital accumulates in H. The main difference from the results without the externality is that the higher productivity in H leads to a larger equilibrium capital stock in H (and a smaller one in F). This leads to a lower home *Y* price in the long run and a larger real depreciation. Because the capital stocks in the initial steady state are the

[22] Specifically, Saxenian (1994) compares Silicon Valley to Route 128 (Boston).
[23] The total factor productivity coefficient at home is recalibrated so that the model is in the same initial steady state as before.
[24] Recall, however, that firms are assumed to treat aK^{ψ} as given in their profit maximisation problem.

same as before, the initial appreciation is also the same. Real GDP becomes higher in H (and lower in F) in the long run, though real GNP is higher in both countries.

Despite the fact that $\psi>0$ raises the degree of homogeneity of H's *Y* production function, (Equation 1), there is no agglomeration of this industry into the home region. This is because the *fixed factors effect* opposes the movement of labour into the home *Y* industry. Indeed, part of the benefit of the home externality is captured by workers, through higher wages. Moreover, the model eventually converges on a new steady state just as it does with no externality.

Large externality - $\psi=0.5$

This is the knife-edge case where the MP_K^H does not depend on the capital stock – there are no longer diminishing returns to capital. The return to capital in the home country depends on the initial level of total factor productivity (a), the amount of labour in *Y* production, as well as the home prices of *Y* and of capital goods. As before, a 10% increase in productivity in H leads to capital inflow into H, a current account deficit in H and a real appreciation due to the *investment demand* effect. As home *Y* output increases with the larger capital stock, the *product differentiation effect* becomes stronger, leading to a larger real depreciation (Figure 7).

After an initial slowing of growth due to the depreciation of the exchange rate (making investment in H less attractive), the capital stock in H continues to grow (Figure 8), as does the current account deficit as a percentage of GDP (Figure 7). Along with labour movements, this leads to a substantial long run increase in *Y* output in H, with a small reduction in home *X* output. *Y* output in F falls as it specialises in *X*, in which it develops a comparative advantage. The relative stability of the output of X_H, X_F and Y_F stems from the product differentiation effect by country of origin, which retards substitution between regional varieties.[25]

As before, the initial productivity shock and accumulation of capital in H leads to rising real GNP in both countries, as indicated in Figure 9. This is driven by the same forces as when there is no externality. In this case, however, the distribution of income is more uneven, because (i) the home country controls a larger capital stock, (ii) the externality not only raises the home capital returns but also MP_L^H in the *Y* industry, and hence the home wage, (iii) home land rent increases due to the increase in the price of home *X*, and (iv) home *Y*, which is now cheaper and more plentiful, has a larger weight in H's utility function due to home consumption bias.

From Figure 8 it appears that the capital stock in the home country is increasing without bound. Yet simulations over longer time periods reveal that the rate of growth of the capital stock in H is falling, which suggests that the model may be slowly converging to a new steady state. This is supported by Figure 10, which shows a falling return to capital in H in the long run. The net return to capital in H, from (Equation 9), falls because of the *capital price effect*. In the long term, the price of home *Y* falls substantially relative to that of home *X*. Because both home *X* and *Y* are required to produce new capital, as in (Equation 8), the price of a new unit of capital falls more slowly than that of *Y*, decreasing P_Y/P_K and thereby reducing the net return to capital.

A very large externality- $\psi=0.75$

Larger externalities can overcome the *capital price effect*. For $\psi>0.6$, the return to capital (and hence the rate of capital accumulation) does not fall over time in the home country. Consider the case of $\psi=0.75$. The externality is so large that an extra unit of capital

[25] Thus, even with an enlargement of the capital stock in H, agglomeration of the high-tech industry does not occur in H.

in H increases total factor productivity more than it crowds existing capital, so the return to capital *rises* over time (Figure 11). This attracts even more capital, leading to explosive behaviour in the home capital stock (Figure 12), the home current account deficit (Figure 13) and GDP (Figure 14). As the home country's *Y* becomes more abundant, its price falls continuously, leading to larger falls in the real exchange rate (due to the *product differentiation effect*).

The foreign *Y* industry is unable to compete with increasingly productive home *Y*. Foreign *Y* production falls (as does foreign GDP). The foreign capital stock declines and its labour moves into the foreign *X* industry. Because the growth in the home *Y* industry is now self-sustaining, all of these trends continue in the long term, with foreign *Y* production contracting asymptotically.[26] Despite this, real income in the foreign country is *higher* as a result of the larger externality, due to greater capital income from the home country and F's more favourable terms of trade.

These and other applications of the model confirm that a one-off productivity shock in the presence of a home an externality causes agglomeration of the high-tech industry (*Y*) if ψ , exceeds a threshold that lies above 0.5. With the parameterisation used this threshold value is approximately 0.6. Agglomeration requires that it be greater than 0.5 because returns to the internationally mobile factor (capital) must be non-decreasing so that the *fixed factors effect* will not oppose the movement of labour into the *Y* industry. If, however, $0.5 \leq \psi < 0.6$ (approximately), the MP_K^H will increase, while net returns will fall due to the higher relative price of capital.

As in the case of no externality, the productivity shock causes an initial appreciation in the real exchange rate, but then a real depreciation. The larger the externality, however, the larger is the eventual depreciation. If the externality is large enough to cause agglomeration,

[26] Its expiry is never complete because the nested CES consumption demand system requires at least some consumption of foreign *Y* in both regions.

the real exchange rate will continue to fall in the long run. The larger the externality, the larger also is the gain in global welfare, though the majority of the gains accrue to the country with the externality. In the long run, higher real incomes accrue to all factors in both countries, with the largest increase accruing to capital owners.

Recall that the "new economy" theory required technological progress that enabled labour productivity to continue to increase in the long term. In the model used here, rising productivity and income in the long term require that the return to capital should be steady, or at worst falling slowly, and financial capital should continue to flow into the home country in the long term. This only occurs if $\psi \geq 0.5$, meaning that the externality would have to be large enough for *an extra unit of capital to add as much (or more) to output through its effect on total productivity as it adds directly*. Empirically this seems somewhat unlikely.[27]

Externalities in both countries

It is likely that the industrial structure of Silicon Valley and similar regions in the US gave it larger positive externalities than other regions. In all high-tech industy, however, productivity depends on the skills of the workforce and the knowledge gained from past research. Our model does not deal with the sources of externalities directly, but we can make positive externalities a feature of the high-tech industries in *both* countries. This does not complicate the results substantially (detailed results available from the authors). The foreign externality merely amplifies the effect of any change in the capital stock. When the 10 per cent productivity shock is restricted to H as before, capital is attracted to the home country,

[27] The empirical literature has some difficulty in determining the size of spillover externalities. However, in general it tends to suggest that the impact of spillovers is at most approximately equal to the effect of firms' own R&D. For our model, this suggests a coefficient of ψ equal to or less than 0.5 – which is not large enough to produce agglomeration. For example, Bottazzi and Peri (2003) find that a 10 per cent increase in R&D spending in a European region increases the number of patents in the same region by around 9 per cent, but only leads to a 0.3 per cent increase in the number of patents in neighbouring regions and has no effect on innovation further away. This suggests that any spillovers are either small or very localised. While Jaffe (1986) finds evidence of a much larger spillover effect (an elasticity of 1.1 of innovation with respect to other firms' R&D, compared constant returns for firms' own R&D), he admits that such a coefficient could reflect firms strategic response to other firms' R&D, rather than spillover effects *per se*.

leading to higher productivity (as before) and further capital inflow. But it also leads to *lower* capital in F, which then decreases productivity, leading to an even smaller foreign capital stock. Hence, the presence of externalities in both regions generally amplifies the earlier results and the distributional disparities that stem from the home productivity shock. Nonetheless, agglomeration of capital in the home country still only occurs with very large externalities ($\psi > 0.5$).[28]

Further simulations with externalities in both countries reveal that if the home country initially starts with a larger high-tech industry (as characterised by a larger capital stock), then agglomeration will only occur with very large externalities. If externalities are not large enough, H's advantage will only be temporary. If H were to achieve its productivity gain earlier than F, its advantage would only be temporary unless externalities in both countries were very large.[29]

These simulation results imply that the forces that attract capital to the US are made even stronger by a second externality in Europe. Although this counts against opponents of the 'new economy' theory (who might take the view, for example, that the US's industrial structure was no different to Europe's), it does not support the 'new economy' camp either. Long run predictions of continued capital flows into the US would only be correct if the externalities in both countries were very large ($\psi > 0.65$) or if Europe *never* "implemented" the internet to get the same once-off productivity benefits the US did. Both cases are rather unlikely, meaning that capital inflows into the US would either quickly peter out, or eventually reverse. And as before, even in presence of large externalities, any appreciation of the real exchange rate is short lived, and a real *depreciation* occurs in the long run.

---

[28] The capital price effect works in the opposite direction in the foreign country, with a lower X price (relative to P_Y) lowering capital prices, and increasing returns...
[29] Further details concerning the case where externalities apply in both countries are available from the authors.

Finally, arguments that the economies of scale that stem from the larger US high-tech industry lead to sustained high US bond yields and therefore continuous capital inflow are not valid unless the externalities are very large ($\psi \geq 0.65$). For more modest externalities, the forces towards symmetry are stronger than those opposing it, assuming that the production technologies used by the two regions are similar. Even if the home externality is large enough to cause continued capital inflow, while the short run effect on the real exchange rate is an appreciation, it would eventually depreciate, moving in the opposite direction to that predicted by the "new economy" analysts.[30].

Very large externalities and economic geography

The results presented here with very large externalities are similar to those in the endogenous growth and economic geography literatures – a small initial advantage in the home country leads to an agglomeration of high-tech industry in that country ("industrial core"), with the foreign country becoming the "agricultural periphery". The main difference is that the faster growth in high-tech production in H is at the expense of F, whereas in Lucas's (1988) model of learning by doing, F would continue to "learn" and grow, but just at a slower rate than H. The prediction of a constantly depreciating real exchange rate is, however, the same as is implied by Lucas (1988). In further simulations a delayed productivity shock in F confirms that history can matter – a "head start" in high-tech industry, or an initially larger industry, leads to a *permanently* higher growth rate at home – the same result as Grossman and Helpman (1991) and Lucas (1988).[31] This behaviour only arises, however, if the externality is very large, at a level that is difficult to rationalise empirically.

[30] That is, the 'new economy' analysis would expect an appreciation of the US dollar in the long term.
[31] Strictly, Lucas (1988) and Grossman and Helpman (1991) deal with the issue of hysteresis, though those initial conditions (generally) lead to permanently higher productivity, so one can also think of them as being driven by a productivity shock.

6. Adaptive expectations over bond yields

If agents hold adaptive expectations of the form specified in Equation 6, the key results are little changed. The main effect is that capital flows are more persistent because expected international returns are more persistent, and this smoothes the movement of macroeconomic variables in the wake of the productivity shock.[32] Figure 15 shows the response of the economy to a 10 per cent productivity shock in H when financial investors have adaptive expectations over bond yields and there is no externality. Compared with the case of myopic expectations, the magnitude of the initial real appreciation (Figure 4) is reduced by three quarters. This is because it takes time for agents adjust their expected returns, and so financial capital flows into H are initially not as strong. H's appreciation and current account deficit peaks in the second period, with slower adjustment to the same new steady state as with myopic expectations.

Adaptive expectations only have a substantial medium term effect when savers are more sensitive to differences in returns across countries. In the foregoing analysis we have assumed that the elasticity of substitution between regional bonds is $\sigma_B=2$. Figure 16 shows the response of the economy to a 10% productivity shock when $\sigma_B=4$. With adaptive expectations, the response of the current account and real exchange rate is cyclical with the disturbances slowly diminishing in amplitude around the new steady state. Investment, capital flows, real GDP, real GNP, *Y* output and real wages are all positively correlated with the exchange rate in the home country (and negatively correlated in the foreign country).[33] Cycles only occur, however, when returns across countries are converging. In the presence of

[32] This persistent real exchange rate behaviour is akin to the results of Evans and Lyons (2004), who explore the role of costly information in exchange rate dynamics.

[33] X output and the size of the capital stock are negatively correlated with the exchange rate in the home country. That is, when the capital stock is low in the home country, the greater demand for investment pushes up prices, the real exchange rate and Y production. It is interesting that in these simulations, the movement of labour from X to Y production (driven by investment demand) more than compensates for the movement of capital.

very large externalities, returns across countries tend not to converge, and so there are no medium-term economic cycles.

Oscillatory convergence to a new steady state is not unrealistic when it is considered that rational but incompletely informed agents resort to "rules of thumb" when there is uncertainty about the new structure of the economy (De Grauwe and Grimaldi 2004). The frequency, violence and persistence of the cycles in this model depend on (i) how sensitive investors are to differences in expected returns, (ii) the weight that investors put on past expectations – the more heavily they rely on past expectations, the lower the frequency of cycles, and (iii) although it is not reflected in the model presented here, an important factor is how quickly investors learn the new structure of the economy - the more quickly they learn, the less persistent the cycles.

7. Conclusions

There is substantial evidence that the US information technology boom did lead to a pick up in US productivity growth in the late 1990s, and that anticipation of its effects contributed to high levels of investment, financial inflows and to a real appreciation of the US dollar. This paper explores the qualitative effects of such a productivity gain on the real exchange rate, financial capital flows and welfare in the short and long runs and asks under what circumstances might there have emerged a self-sustaining advantage to the US over its foreign trading partners. The effects are examined using a dynamic model of two freely trading regional economies with open capital accounts, under constant returns to scale and with production externalities of varying size.

With small or no externalities, the productivity shock only has significant effects in the short-to-medium term. The increase in productivity in one region attracts investment. This leads to an inflow of world savings, increasing investment demand for the region's products, raising domestic prices and leading to a real appreciation relative to the other region. In the medium term, bond yields in the advantaged region decline and savers rebalance their portfolios, leading to a real depreciation towards PPP. Because the advantaged region is now more productive, its prices are lower and hence there is a permanent real depreciation. In the long run, both regions are better off with gains to the disadvantaged region stemming from higher capital returns and an improvement in its terms of trade.

With larger externalities the path of the real exchange rate is similar. If the gains in productivity from the externality exactly balance the losses from diminishing returns to capital in the favoured region, capital inflows are much more persistent, but returns eventually fall due to higher relative capital goods prices (the *capital price effect*). The exchange rate appreciates by the same amount in the short term, but the larger externality means that it depreciates by more in the long term (due to the *product differentiation effect*).

If the externality is substantially larger than that in the balancing case, then bond yields in the favoured region rise without bound as does that region's capital stock, and the pace of capital accumulation in that country. The real exchange rate depreciates without bound. Unlike results with smaller values of the externality, the foreign region suffers an asymptotic decline in its high-tech industry, and specialises in low-tech production. However, GNP rises in both countries, with the majority of the gain accruing to the advantaged region.

Adding externalities in both countries generally produces similar results, though it amplifies differences between regions. So long as the production externalities are not too large, the advantages of starting with a larger high-tech industry, or having an earlier productivity grain, are only temporary. Finally, if investors hold adaptive expectations over regional bond yields, then the real appreciation that follows the productivity improvement takes several periods to peak, and convergence to any new steady state can be oscillatory. If expectations were, in fact, driven by rules of thumb of this type, the behaviour of the model could explain the "persistence" of real exchange rate movements observed over the same period.

With reference to the perceived "new economy" of the 1990s in the US and the expectation that it would lead to an appreciating dollar and persistently higher returns to capital, our simulations are generally unsupportive. Even if the US IT industry did have positive externalities, sustained increases in real returns would only have occurred if the externalities were so unrealistically large as to more than offset diminishing returns to capital. And even then, the US dollar would not have kept appreciating. Indeed, the long run path would show a substantial real depreciation.

References

Acz, Z., Audretsch D., and Feldman, M. (1994), 'R & D Spillovers and Recipient Firm Size', *The Review of Economics and Statistics,* 76, 2 pp. 336-340.

Armington, P. (1969),"A theory of demand for products distinguished by place of production", *IMF Staff Papers* 16: 159-178.

Bailey, M. N. (2002) "Distinguished Lecture on Economics in Government: The New Economy: Post Mortem or Second Wind?" *The Journal of Economic Perspectives*, Vol. 16, No. 2. (Spring, 2002), pp. 3-22.

Balassa, B., 1964. 'The purchasing power parity doctrine: a reappraisal', *Journal of Political Economy*, 72(6): 584-596.

Baldwin, R. (1998), "Agglomeration and endogenous capital", *European Economic Review* No. 43 (1999) 253-280.

Baldwin R. and Krugman P. (1992), "Market Access and International Competition: A simulation study of 16K Random Access Memory", in Grossman G. (eds), *International Competition and International Trade*, Cambridge MA: The MIT Press.

Barro, R. and Sala-i-Martin, X. (2004), *Economic Growth*, 2nd Edition, MIT Press, Cambridge MA.

Bergin, P.R., R. Glick and A.M. Taylor, 2006. 'Productivity, tradability and the long run price puzzle', *Journal of Monetary Economics*, 53(8): 2041-2066, November.

Bosworth, B. and J. Triplett (2007), "The 21st century productivity expansion is still in services", NBER Productivity Program Workshop, Cambridge MA, March.

Bottazzi, L. and Peri, G (2003), 'Innovation and spillovers in regions: Evidence from European patent data', *European Economic Review*, 47, 687-710

Crucini, M.J., Telmer, C.I. and Zachariadis, M. (2005), 'Understanding European real exchange rates', *American Economic Review*, 95(3):724–38.

De Grauwe, P. and M. Grimaldi (2004), "Bubbles and crashes in a behavioural finance model", Sveriges Riksbank Working Paper No. 164, Stockholm, May.

Devereux, M. (1997), "Real exchange rates and macroeconomics: Evidence and Theory", *The Canadian Journal of Economics*, 30(4a): 773-808, November.

Dixon P.B., B.R. Parmenter, J. Sutton and D.P. Vincent (1982), *ORANI, a Multi-Sectoral Model of the Australian Economy*, Amsterdam: North Holland.

Dornbusch R. (1976), "Expectations and exchange rate dynamics", *The Journal of Political Economy*, Vol. 84, No. 6. (Dec., 1976), pp. 1161-1176.

Engel, C. (1993), "Real exchange rates and relative prices: an empirical investigation", *Journal of Monetary Economics* 32: 35-50.

Engel, C. and J.H. Rogers (2001), "Deviations from purchasing power parity: causes and welfare costs", *Journal of International Economics* 55: 29-57.

Evans, M.D. and R.K. Lyons (2004), "A new micro model of exchange rate dynamics", NBER Working paper 10379, Cambridge MA, March.

Fleming, J. M. (1962), "Domestic financial policies under fixed and under floating exchange rates" *I.M.F. Staff papers* 9 (November 1962): pp. 369-79.

Feldstein M. and C. Horioka (1980), "Domestic Saving and International Capital Flows", *Economic Journal,* 90: 314-29, June.

Ghironi, F. and M.J. Melitz (2005), "International trade and macroeconomic dynamics with heterogeneous firms" The Quarterly Journal of Economics, 120(3): 865-915.

Gordon, R (2000), "Does the 'new economy' measure up to the great inventions of the past?" *The Journal of Economic Perspectives*, 14(4): 49-74, Autumn.

______ (2003), "Exploding productivity growth: context, causes and implications", *Brookings Papers on Economic Activity*, 2: 207-297.

______ (2006), "The US productivity growth 'explosion': dimensions, causes, consequences and aftermath", 48th Annual Meeting of the NABE, NBER Session, Boston, 11 September.

______ (2007), “Comments on ‘A retrospective look at the US productivity growth resurgence’”, American Economics Association Conference session, 6 January.

Greenspan, A. (1998), Speech at Haas Business School, UC Berkley, 4th Sept 1998.

Grossman, G. and E. Helpman (1991), *Innovation and Growth in the Global Economy,* Cambridge MA: The MIT Press.

Jaffe, A. (1986), ‘Technological Opportunity and Spillovers of R & D: Evidence from Firms’ Patents, Profits and Market Value’, *The American Economic Review*, 76, 5, 984-1001.

Jaffe, A., Trajtenberg, M. and Henderson, R. (1993), ‘Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations’, *The Quarterly Journal of Economics*, 108, 3, 577-598.

Jorgenson, D.W., M.S. Ho and K.J. Stiroh (2007), “A retrospective look at the US productivity growth resurgence”, Federal Reserve Bank of New York Staff Report No. 277, February.

Krugman, P. (1991), “Increasing returns and Economic Geography”, *The Journal of Political Economy*, 99(3): 483-499, June.

Krugman, P and A. Venables (1990), “Integration and the competitiveness of peripheral industry”, in Bliss, C. and J. Braga de Macedo (eds.), *Unity with Diversity in the European Community*, Cambridge University Press.

Kydland, F and E. Prescott (1982), “Time to build and aggregate fluctuations”, *Econometrica*, 50: 1345-70, November.

Lucas, R.E. (1988), “On the mechanics of economic development”, *Journal of Monetary Economics*, 22: 2-42.

Lucas, R.E. (1982), “Interest Rates and Currency Prices in a two-country world” *Journal of Monetary Economics*, 10: 335-359.

Macfarlane, I.J. (2001) “Recent influences on the exchange rate”, Speech to CEDA Annual General Meeting Dinner, Melbourne, 9 November 2000 (http://www.rba.gov.au/PublicationsAndResearch/Bulletin/bu_dec00/bu_1200_1.pdf)

Mann, C. L. (2002), “Perspectives on the U.S. Current Account Deficit and Sustainability”, *The Journal of Economic Perspectives*, Vol. 16, No. 3. (Summer, 2002), pp. 131-152.

Meese, R. and K. Rogoff (1983), “Empirical models of the exchange rate: do they fit out of sample?” *Journal of International Economics*, 14: 3-24.

Mundell, R. (1963), “Capital mobility and stabilization policy under fixed and flexible exchange rates”, *Canadian Journal of Economics and Political Science* 20, pp. 475-85

Oliner, S.D. and D.E. Sichel (2000), “The resurgence of growth in the late 1990s: is information technology the story?” *Journal of Economic Perspectives*, 14: 3-22, Fall.

Romer, P. (1990), "Endogenous Technological Change", *Journal of Political Economy*, 98(5): S71-S102.

Saxenian, A. (1994), *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*, Cambridge MA: Harvard University Press.

Solow, R. (1956), "A contribution to the theory of economic growth", *The Quarterly Journal of Economics*, 70(1): 65-94, February.

Samuelson, P., 1964. 'Theoretical notes on trade problems', *Review of Economics and Statistics*, 46(2):145-154.

Stockman, A. (1988), "The equilibrium approach to exchange rates", *Federal Reserve Bank of Richmond Quarterly Review*.

Swan, T. (1956), "Economic Growth and Capital Accumulation", *Economic Record*, 32: 334-61.

Tyers, R. and J. Golley (2007), "China's real exchange rate puzzle", Working Paper No.14/2007, Centre for Applied Macroeconomic Analysis (CAMA), Australian National University, Canberra.

Tevlin S and K Whelan (2003), "Explaining the investment boom of the 1990s", *Journal of Money, Credit and Banking*, 35(1): 1-22.

Venables, A. (1996), "Equilibrium Locations of Vertically Linked Industries", *International Economic Review*, 37(2): 341-359, May.

Figures

Figure 1

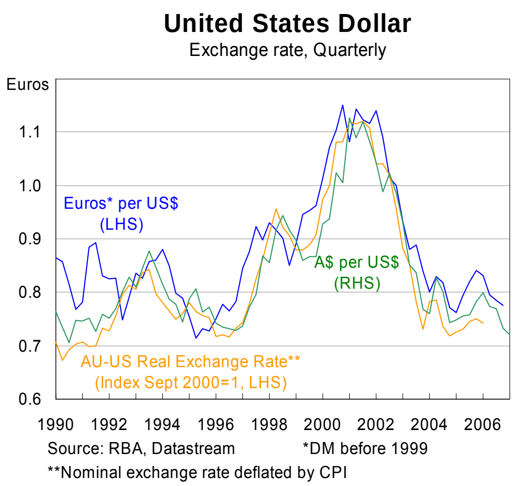

Figure 2

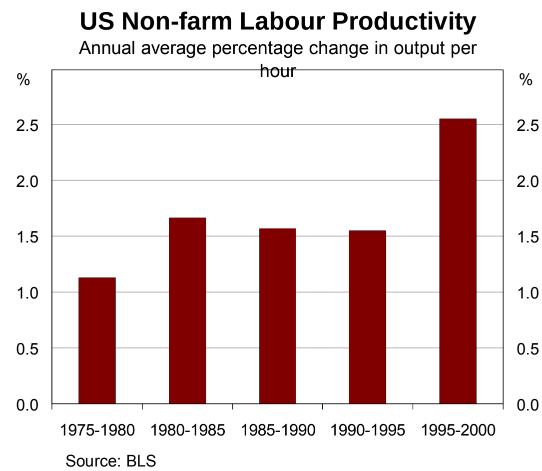

Figure 3: Productivity Shock with No Externality

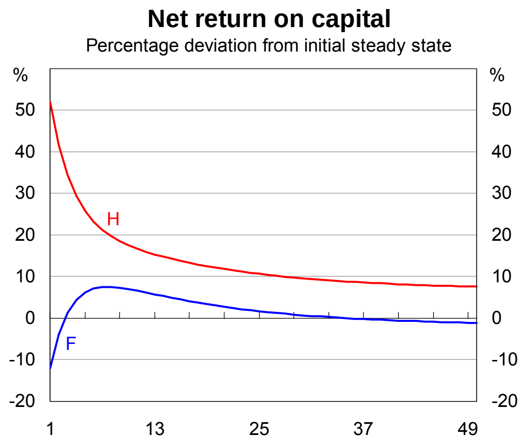

Figure 4: Productivity Shock with No Externality

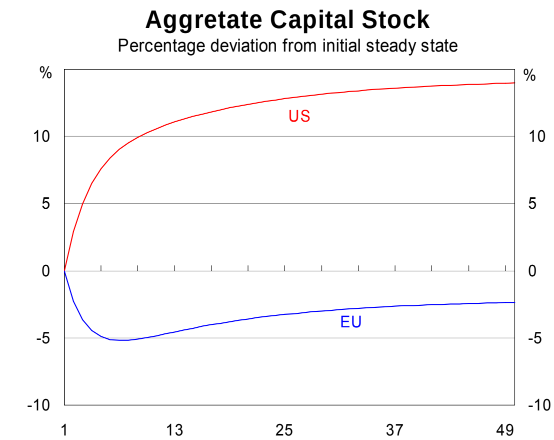

Figure 5: Productivity Shock with No Externality

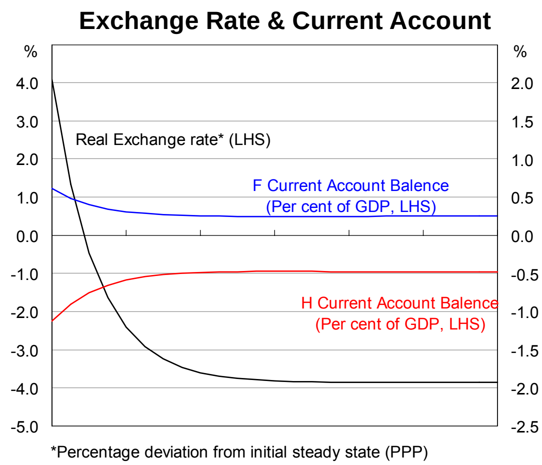

Figure 6: Productivity Shock with No Externality

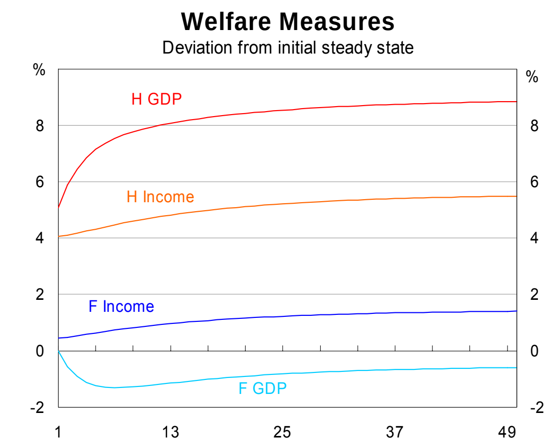

Figure 7: Productivity Shock, Large Externality

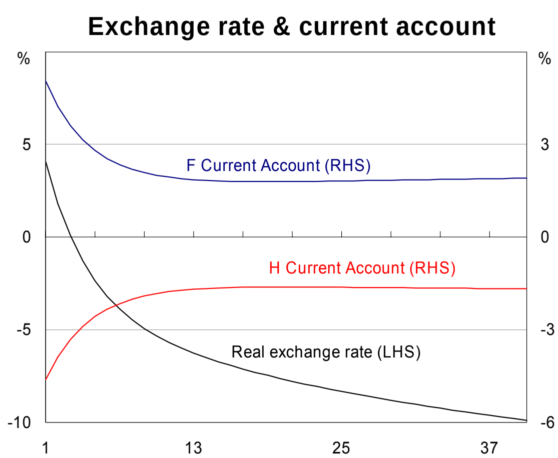

Figure 8: Productivity Shock, Large Externality

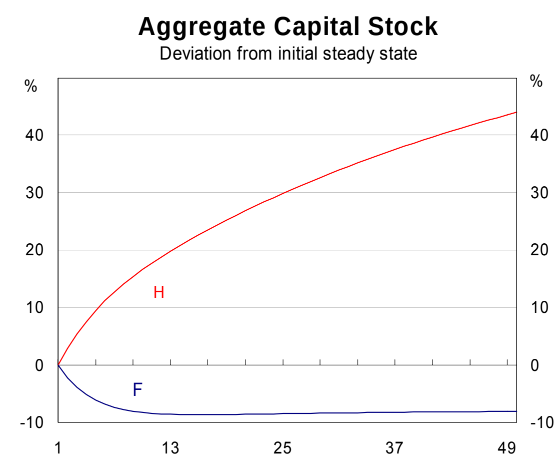

Figure 9: Productivity Shock, Large Externality

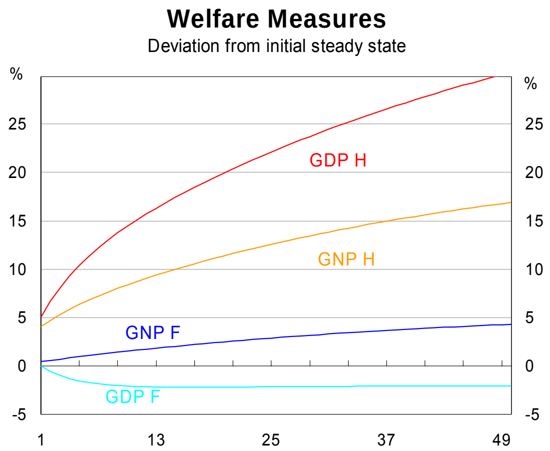

Figure 10: Productivity Shock, Large Externality

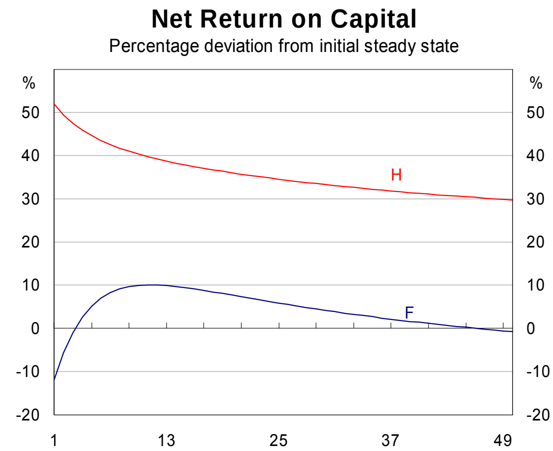

Figure 11: Prod. Shock, Very Large Externality

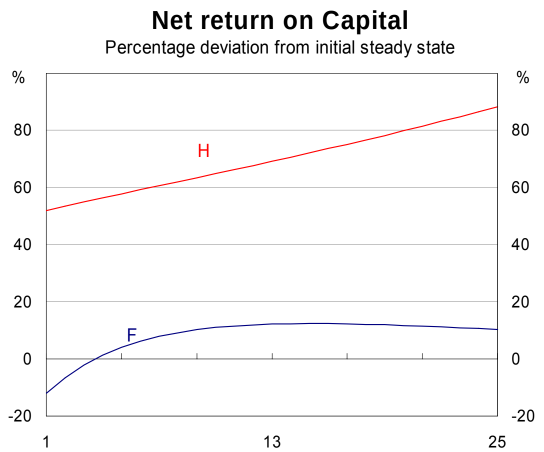

Figure 12: Prod. Shock, Very Large Externality

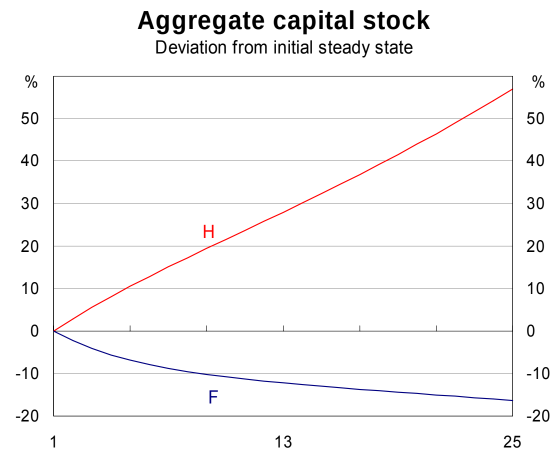

Figure 13: Prod. Shock, Very Large Externality

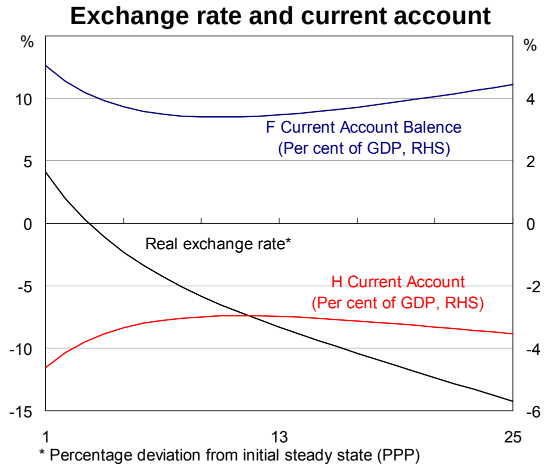

Figure 14: Prod. Shock, Very Large Externality

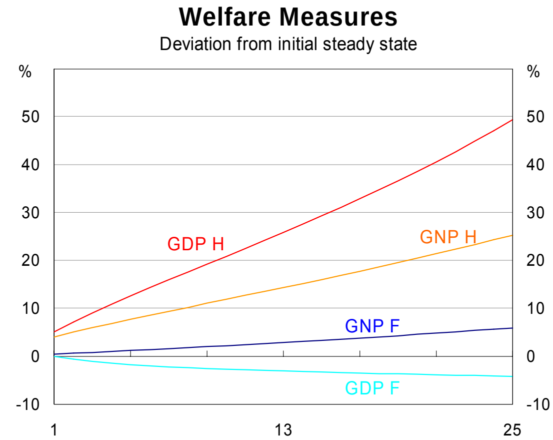

Figure 15: Productivity Shock with Adaptive Expectations

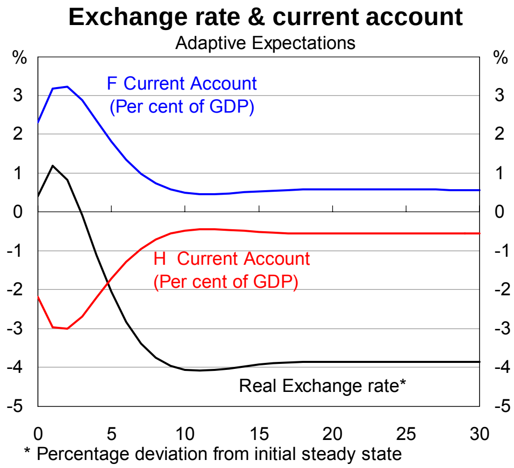

Figure 16: Productivity Shock with Adaptive Expectations

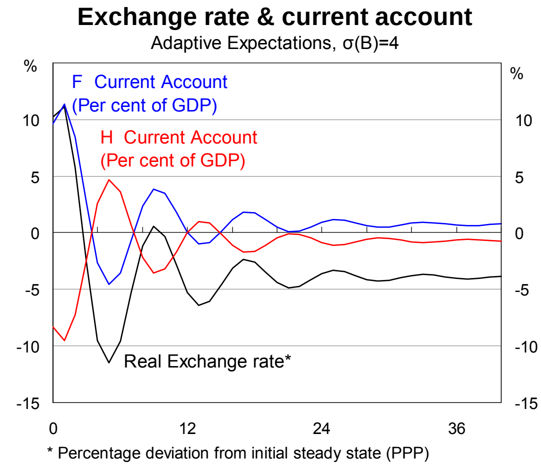

Table 1: The Initial Steady State and Key Parameters[a]

Variables and base values		Key parameters	
Variable	Base value	Parameter	Value
Volumes:		*Rates*	
GDP	2.0	Saving rate from GNP, s	0.2
Output, X	1.0		
Output, Y	1.0	*Share parameters*	
Consn, C_X	0.9	Home weight in bond portfolio, α_{iH}	0.5
Consn, C_Y	0.7	Production share of labour in X	0.5
Inv goods demand, I_X	0.1	Production share of labour in Y	0.5
Inv goods demand, I_Y	0.3	Generic X consumption share γ	0.5
Exports, X	0.3	Home share of X consn, $\phi_{X,H,H}^{\sigma_C}$	0.666
Exports, Y	0.233	Home share of Y consn, $\phi_{Y,H,H}^{\sigma_C}$	0.666
Imports, X	0.3		
Imports, Y	0.233		
Factor quantities		*Elasticities of*	
Land supply, N	4.0	consumption substitution, σ_C	2.0
Labour supply, L	2.0	X,Y substitution in investment, σ_I	2.0
Capital stock, K	4.0	*H-F bond substitution,* σ_B	2.0
Foreign-owned capital	2.0		
Domestically owned capital	2.0	*Other parameters*	
		Lagged adjustment parameter, λ	0 (or 0.5)
Prices:		Depreciation rate, δ	0.1
Wage, w	0.5		
Net rate of return on capital, r	0.025		
Land rent, n	0.125		
p_X	1.0		
p_Y	1.0		
p_X foreign	1.0		
p_Y foreign	1.0		
CPI	1.0		
GDP price	1.0		
Real exchange rate	1.0		

a) Note that both regions are identical in the initial steady state. The details given here are for a single region.