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Global Effects of US “New Economy” Shocks: the Role of Capital-Skill Complementarity*

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Abstract

We characterise “new economy” shocks as capital or skill augmentation, associated with the increasing prominence of computers in the capital stock particularly in the US, and an increase in US investment at least partially financed from abroad. A short-run comparative static analysis of these shocks using a global comparative static multi-product macroeconomic model confirms that the US technology shocks alone expand the US and global economies. The investment shock, however, is associated with a flood of foreign savings into the US economy the effects of which are more “zero sum” in nature. In the US the technology shocks alone advantage agriculture and mining by more with capital-skill complementarity but they are disadvantaged, however, by the real exchange rate effects of the investment shock. The combined US shocks contract the Canadian and Australasian economies though the net effects on their agricultures are small and mining gains.

1. Introduction

The long boom that began in the 1990s in the US has recently been shown to be underpinned by strong growth in labour productivity.¹ Moreover, it appears to be associated with extraordinary growth in the information technology sector and with the spread of its products and services throughout the economy.² This process is causing a dramatic change in the composition of the capital stock. The new information technology is declining in price relative to other capital so that its value share is rising less quickly than its productivity.³ Yet, in the US at least, there has nonetheless been a substantial rise in the value share of “equipment” and a corresponding decline in the share of “structures”.⁴ Growth in the “effective” capital stock has therefore accelerated. To the extent that capital, and more particularly equipment, is complementary with skill, this is likely to explain recent growth in the skill premium in the US.⁵ Expectations associated with the information technology boom also explain a significant rise in US investment during the 1990s, financed at least in part by savings from abroad.

¹ See, for example, Oliner and Sichel (2000), who analysis the observed “one percentage point step-up in productivity growth between the first and the second halves of the decade” of the 1990s.

² The analysis by Oliner and Sichel (2000) accounts for the special effects of computer obsolescence highlighted by Whelan (2000) and attributes about two thirds of the half-decade productivity step-up to (i) increased output in the computer and software production industry and (ii) increased use of information technology in other sectors.

³ See Greenwood et al. (1997, 2000: Figure 1).

⁴ See Krusell et al. (1997), Figure 1.

⁵ See Krusell et al. (1997) and Tyers and Yang (2000).

In the extensive recent literature on the determinants of the relatively poor labour market performance by unskilled workers a prevalent conclusion is that this is due to technical change and, in particular, skill-biased change due to automation associated with the introduction of computers.⁶ One clear statement of the technical implications of this finding is by Kahn and Lim (1998). They take the view that skill and labour have a larger than unit substitution elasticity and that computer-based automation enhances skilled labour time, increasing “effective” skill hours per actual skilled worker and hence raising the marginal product of skilled relative to unskilled workers.⁷ According to this view, the technical change acts directly to change the factor-specific parameters of the production function.

While there is ample evidence that labour and skill are substitutes, a role for capital-skill complementarity was recognised early on by Griliches (1969) and Fallon and Layard (1975). More recently, Goldin and Katz (1998), took the view that skill-capital complementarity was a key determinant of the US skill premium throughout the 20th century. This view is examined more formally by Krusell et al. (1997) who focus on the US in the period between 1963 and 1991. They conclude that the observed changes in US skill premia can be explained without resort to changes in the fundamental parameters of the production function. They formulate a simple nested CES production system that embodies capital skill complementarity and find that skill premia are explained almost entirely by readily observable factor accumulation. Their results are aided by the disaggregation of the capital stock into “equipment” and “structures”, the incorporation of complementarity between equipment and skill and the implementation of shocks to both the size of the capital stock and its composition.⁸

A parallel analysis of changes in the global economy is carried out using a general equilibrium model by Tyers and Yang (2000). They construct a backcast over two decades in which observed changes in aggregate productivity and the skill premium are imposed as exogenous while technical parameters are made endogenous. This approach has the

⁶ Sachs and Shatz (1994) and Wood (1994), among others, find some role for trade, while Abraham and Taylor (1996) and Feenstra and Hansen (1996) focus on the contribution of out-sourcing and its associated effects on both trade and home technology. Haskel and Heden (1999) and Haskel and Slaughter (1998, 1999) emphasise the evidence favouring skill-biased technical change associated with computerisation. The dominance of the latter is confirmed for the U.S. in a more recent empirical analysis by Morrison Paul and Siegel (2000).

⁷ When substitution between labour and skill is elastic, the unit isoquant is drawn further inward the more skill intensive is the technique and so, even at constant factor prices, the cost share of skill rises. The common presumption that automation enhances labour (is “labour saving”) is only consistent with a rise in the skill share if the elasticity of substitution between skill and labour is less than unity.

⁸ This disaggregation is also used by Kahn and Lim (1998).

advantage that it also enabled them to control for other relevant macroeconomic shocks, including changes in trade distortions and in labour market policy. For the many regions included in that study, however, data on the composition of capital stocks were unavailable. When capital-skill complementarity is incorporated into all technologies, their results therefore characterise the technical change that occurred in the last two decades as primarily “capital augmentation”, reflecting unobserved compositional changes in capital stocks. Moreover, this type of technical change is shown to have been most rapid in the US during this period.

They also compare the implied pattern of technical change as between the case where the base technology has capital-skill complementarity on the one hand and capital-skill substitution on the other. When skill and capital are represented as substitutes, the implied technical change is skill-enhancement. Although the empirical evidence tends to support the model with capital-skill complementarity,⁹ both technology characterisations could be consistent with the observed pattern of long run technical change. Where they differ, however, is in their implications for short run behaviour. In the short run the physical capital stock is sector-specific. A capital enhancement, say due to a short run compositional change associated with information technology acquisition, changes the return on installed capital. This changes the sectoral pattern of investment and output according to capital intensity. A skill enhancement on the other hand changes the sectoral pattern of the rate of return on installed capital according to skill intensity, leading to different implications for investment and output.

In this paper we explore these short run implications of skill-capital complementarity by examining the simulated response of the world economy to US “new economy” shocks. In particular, we examine the global implications of a technical change shock in the US alone and then combine it with an investment shock so that the associated US expansion is financed in part from abroad, following the pattern of the late 1990s. We use a global comparative static multi-product macroeconomic model based on that introduced by Yang and Tyers (2000). In order to focus on capital-skill complementarity, for each region and each industry within it we depart from the traditional representation of factor

⁹ See, for example, Hamermesh (1993).

demand in such models¹⁰ by constructing alternative nested CES production systems, with and without skill-capital complementarity.

The model used is described in Section 2 and our construction of the alternative technologies is discussed in Section 3. The technology and investment shocks and their implications are presented in Section 4 and Section 5 concludes.

2. A Global Model for Short Run Comparative Statics

The original parent of the model used is the GTAP general equilibrium framework.¹¹ In its original form, it is a conventional neoclassical multi-region comparative static model in real variables with price-taking households and all industries comprising identical competitive firms. Yet it offers the following useful generalisations: (1) a capital goods sector in each region to service investment, (2) explicit savings in each region, combined with open regional capital accounts that permit savings in one region to finance investment in others, (3) multiple trading regions, goods and primary factors, (4) product differentiation by country of origin, (5) empirically based differences in tastes and technology across regions, (6) non-homothetic preferences, and (7) explicit transportation costs and indirect taxes on trade, production and consumption.

In the original model, each regional household receives all income from primary factors and indirect taxes on trade, production and consumption. Its expenditure is then a Cobb-Douglas composite of private consumption, savings and “government expenditure”. Private consumption is then a CDE composite of goods and services while government expenditure is a corresponding CES composite.¹² All individual goods and services entering final and intermediate demand are CES blends of home products and imports. In turn, imports are CES composites of the products of all regions the content of which depends on regional trading prices. Savings are pooled globally and investment is then allocated between regions from the global pool according to rules that accommodate a range of assumptions about international capital mobility. Within regions, investment places demands on the domestic capital goods sector which is also a CES composite of home produced goods,

¹⁰ It has been the accepted practice in general equilibrium analysis to assume simple factor demand structures implying unit elasticities of substitution between capital and labour. See Shoven and Whalley (1992: 5.4) and Dixon et al. (1992: 220). For an application to labour markets, see Burfisher et al. (1994).

¹¹ For a detailed description of the standard version of this model, see Hertel (1997).

¹² CDE is “constant difference in elasticities”. It allows empirically supported differences in income elasticities of demand across products and services. See Huff et al. (1997).

services and imports in the manner of government spending. The primary factors identified are land, natural resources, labour, skill and physical capital. Skill is separated from raw labour on occupational grounds, with occupations in the “professional” categories of the ILO classification included as skilled.¹³

Now we turn to our adaptation of the model and our modifications to it. Our first major modification to the model code is to make the government financially independent, and so enable more explicit treatment of fiscal policy. Direct taxes are incorporated with the approximation of a fixed marginal tax rate in each region, allowing for the exogeneity of government spending. Regional households then receive only regional factor income, Y_F , and from this they pay direct tax at a constant marginal rate, τ . The disposable income that remains is then divided between private consumption and private saving. Government saving, or the government surplus, S_G , is then simply revenue from direct taxes, τY_F , and indirect taxes, T_I , less government spending, G , which could be exogenous or fixed as a proportion of GDP.¹⁴ Thus, $S_G = T_I + \tau Y_F - G$. The private saving and consumption decision is represented by a reduced form consumption equation with wealth effects included via the dependence of consumption (and hence savings) on the interest rate. Each region then contributes its total saving, $S_T = S_P + S_G$, to the global pool from which investment is derived.

For an individual region, the identities embodied in the above then imply the balance of payments identity, which sets the current account surplus equal to the capital account deficit: $X - M = S_P + S_G - I$.¹⁵ From the pool of global savings, investment is allocated across regions and places demands on regional capital goods sectors. In the short run considered, it does not add to the installed capital stock, however. Also at this length of run, nominal wages are sticky in some regions (the EU, Canada, Australasia and China) but flexible elsewhere. In the spirit of comparative statics, although price levels do change in response to shocks, no continuous inflation is represented and so there is no distinction between the real and nominal interest rates.

¹³ See Vo and Tyers (1995) and Liu et al. (1998) for the method adopted.

¹⁴ T_I includes revenue from taxes on production, consumption, factor use and trade, all of which are accounted for in the original model and database.

¹⁵ Note that there is no allowance for interregional capital ownership in the starting equilibrium. At the outset, therefore, there are no factor service flows and the current account is the same as the balance of trade.

In allocating the global savings pool as investment across regions, we have opted to use the most flexible approach, implying a high level of global capital mobility.¹⁶ The allocation ensures that the proportional change in investment is larger in regions, j , with high values of the average rate of return on installed capital, r_j^c . In this process, a global “expected return”, r^w , is calculated such that $\sum_j S_j^T = \sum_j I_j(r^w, r_j^c, \pi_j)$, where I_j is real investment in region j and π_j is a region-specific risk premium.¹⁷ The investment demand equation for region j takes the form:

$$(1) \quad \frac{K_j + I_j}{K_j} = \beta \left(\frac{1 + r^w(1 + \pi_j)}{1 + r_j^c} \right)^\varepsilon$$

where K_j is the (exogenous) installed capital stock, β is a positive constant and ε is a negative elasticity. The numerator on the right hand side is the expected gross return on investment in region j , so that $(1 + r_j) = (1 + r^w)(1 + \pi_j)$ or $r_j \approx r^w + \pi_j$.

Note that our short run comparative static analysis does not require that the global economy be in a steady state. When shocks are imposed, the counterfactual return on installed capital, r_j^c , need not be the same as the corresponding expected return on investment, r_j . Such shocks, implemented in the current period, change income and savings and, therefore, expected returns in directions that differ from the returns on installed capital, particularly considering that capital is fixed in quantity and sectoral distribution.

To include the monetary sector in each region we simply add *LM* curves. This implies that regionally homogeneous nominal bonds are the only financial assets other than regional money. Even though there is no interregional ownership of installed capital in the initial database these bonds are traded internationally, making it possible for savers in one region to finance investment in another.¹⁸ The yield on the j th region’s bonds in the single period represented by the model is the interest rate, r_j , defined above. Cash in advance constraints then cause households to maintain portfolios including both bonds and non-

¹⁶ By which it is meant that households can direct their savings to any region in the world without impediment. Installed capital, however, remains immobile even between sectors.

¹⁷ Before adding to the global pool, savings in each region is deflated using the regional capital goods price index and then converted into US\$ at the initial exchange rate. The global investment allocation process then is made in real volume terms.

¹⁸ Since the initial database we use (GTAP Version IV) incorporates no “net income” or factor service component in its current account, our initial equilibria must do likewise. This implies the assumption that, although there are no interregional bond holdings initially, the shocks implemented cause interregional exchanges of bonds and hence a non-zero net income flow in future current accounts not represented.

yielding money and the resulting demand for real money balances has the usual reduced form dependence on GDP (transactions demand) and the interest rate. This is equated with the region's real money supply, where purchasing power is measured in terms of its GDP deflator, P^Y .

Since all domestic transactions are assumed to use the home region's money, international transactions require currency exchange. For this purpose, a single nominal exchange rate, E_j , is defined for each region. A single key region is identified (here the US) relative to which these nominal rates are defined. For the US, then, $E=1$ and E_j is the number of US dollars per unit of region j 's currency. In essence, we are adding to the real model one new equation per region and one new (usually endogenous) variable per region, E_j .¹⁹

The bilateral rate between region i and region j is then simply the quotient of the two exchange rates with the US, $E_{ij} = E_i/E_j$. Quotients such as this appear in all international transactions. The most straightforward of these in the original model are trade transactions. There the bilateral exchange rate is simply included in all import price equations, along with *cif/fob* margins and trade taxes. In the case of savings and investment, the global pool of savings is accumulated in US dollars. Investment, once allocated to region j , is converted to that region's currency at the rate E_j . The third, and most cryptic, set of international transactions in the original model concerns international transport services. Payments associated with *cif/fob* margins are assumed to be made by the importer in US dollars. The global transport sector then demands inputs from each regional economy and these transactions are converted at the appropriate regional rates.

Without nominal rigidities the model always exhibits money neutrality, both at the regional and global levels. Firms in the model respond to changes in nominal product, input and factor prices but a real producer wage is calculated for labour as the quotient of the nominal wage and the GDP deflator, so that $w=W/P^Y$. Thus, money shocks always maintain constant w when nominal rigidities are absent. It is in the setting of the nominal wage, W , that we have introduced nominal rigidities to the model. A parameter, $\lambda \in (0, 1)$ is inserted, such that

¹⁹ More precisely, since for the US $E=1$, we are adding one less (usually endogenous) variable. Where nominal exchange rates are to be endogenous and nominal money supplies exogenous, one additional variable must be made endogenous. We could, for example, balance this by making one price level exogenous, such as by having US monetary policy target the change in the US CPI, P^C .

$$(2) \quad \frac{W}{W_0} = \Lambda \left(\frac{P^Y}{P_0^Y} \right)^\lambda$$

where W_0 is the initial value of the nominal wage, P_0^Y is the corresponding initial value of the GDP deflator and Λ is a slack constant. While ever Λ is exogenous and set a unity, the nominal wage carries this relationship to the price level and the labour market will not clear except if equation (2) happens to yield a market clearing real wage. A fully flexible labour market is achieved by setting Λ as endogenous and thereby rendering (2) ineffective. At the same time, labour demand is forced to equate with exogenous labour supply to reflect the clearing market.

Because the length of run is short, the real part of the model incorporates smaller-than-standard elasticities of substitution in both demand and supply. The key elasticities of substitution on the demand side are listed in Table 2. These are set smaller than the standard ones to an extent guided by a short run calibration exercise on the Asian crisis, described in Yang and Tyers (2000). The representation of production technologies is discussed in Section 3, to follow.

3. Production Technology and Factor Demand

We adopt two alternative technologies, both of which are nested CES structures that differ from the original model. Our standard technology is the three level nest illustrated in Figure 1.²⁰ It allows the substitutability between raw labour and skill to differ from that between these and other factors and it makes it possible to vary the degree of substitutability between labour and skill without changing that between other factor pairs.

The weak separability essential to nested CES structures allows the production function to take the following form:

$$(3) \quad Y = \alpha_Y \left[\phi_{VI} (\delta_{VI} VI)^{-\rho_Y} + \phi_{VA} (\delta_{VA} VA)^{-\rho_Y} \right]^{\frac{1}{\rho_Y}}$$

where VI is the composite of intermediate inputs and VA is the value added composite of all primary factors, α_Y , δ_{VI} and δ_{VA} are technology shifters to be used subsequently and ϕ_{CI} and

²⁰ The original model has a two level structure with a Leontief split between intermediates and primary factors (value added) and labour and skill are treated in the same way as the other three factors.

ϕ_{VA} are parameters that depend on the shares of VI and VA in total cost.²¹ Finally, the top-level elasticity of substitution is $\sigma_Y = 1/(1 + \rho_Y)$. Following the primary factor branch of the nest, the value-added composite is then

$$(4) \quad VA = \alpha_{VA} \left[\phi_{VL} (\delta_{VL} VL)^{-\rho_{VA}} + \phi_K (\delta_K K)^{-\rho_{VA}} + \phi_R (\delta_R R)^{-\rho_{VA}} + \phi_A (\delta_A A)^{-\rho_{VA}} \right]^{-\frac{1}{\rho_{VA}}}$$

where VL is value added in labour and skill (a labour-skill composite) and the parameters play the same roles as in (1), above. The elasticity of substitution at this level is $\sigma_{VA} = 1/(1 + \rho_{VA})$. To complete the nest, then, a similar formulation is offered for the labour-skill component of value added, VL :

$$(5) \quad VL = \alpha_{VL} \left[\phi_L (\delta_L L)^{-\rho_{VL}} + \phi_S (\delta_S S)^{-\rho_{VL}} \right]^{-\frac{1}{\rho_{VL}}}$$

where L is raw labour and S is skill and the level-specific elasticity of substitution between them is $\sigma_{VL} = 1/(1 + \rho_{VL})$.

Again, the initial values of the technology shifters α and δ , are unity.²² The combination of (3) – (5) allows the proportional change in the demand for any factor or intermediate input, X_i , denoted lower case as x_i , to be expressed in terms of the corresponding proportional changes in output, y , and proportional changes in all of the factor

$$(6) \quad x_i = y + \sum_j \eta_{ij} p_j$$

prices, p_j , as

where η_{ij} is the conditional elasticity of demand for input or factor i with respect to the price of input or factor j . These demand elasticities, $[\eta_{ij}]$, follow from the Allen partial elasticities of substitution, $[\sigma_{ij}]$ via $\eta_{ij} = \sigma_{ij} \theta_j$, where θ_j is the share of factor or input j in total cost. The Allen partials are conditional (output constant) elasticities of substitution for pairs of inputs when more than two are used and where they are combined in a multi-level nest. In the two-factor single-level case they collapse to the branch elasticity (Allen 1938: 341, Hamermesh 1993: 23, 39). They are symmetric ($\sigma_{ij} = \sigma_{ji}$) and can be derived from the branch elasticities of substitution, σ_Y , σ_{VA} , and σ_{VL} by the method of Keller (1980: Ch.5, Appendix). Those of

²¹ In such CES structures the number of independent parameters is equal to the number of factors or inputs. Here only the ϕ s are independent and derived from the database. The α s and the δ s are shifters set to unity unless the technology changes.

special interest for our present purpose are the own price elasticities for labour, η_{LL} , skill, η_{SS} and capital, η_{KK} and the associated cross price elasticities, η_{LS} , η_{SL} , η_{LK} , η_{KL} , η_{SK} and η_{KS} .

The own price elasticity for labour, for example, takes the following form:

$$(7) \quad \eta_{LL} = -\theta_L \left[\sigma_{VL} (\theta_L^{-1} - \theta_{VL}^{-1}) + \sigma_{VA} (\theta_{VL}^{-1} - \theta_{VA}^{-1}) + \sigma_Y (\theta_{VA}^{-1} - 1) \right]$$

where θ_L is the share of raw labour, θ_{VL} the combined share of labour and skill and θ_{VA} the share of value added in total cost.²³ And the cross elasticities between labour and skill and labour and capital are:

$$(8) \quad \eta_{LS} = \sigma_{LS} \theta_S = \theta_S \left[\sigma_{VL} \theta_{VL}^{-1} - \sigma_{VA} (\theta_{VL}^{-1} - \theta_{VA}^{-1}) - \sigma_Y (\theta_{VA}^{-1} - 1) \right]$$

$$(9) \quad \eta_{LK} = \sigma_{LK} \theta_K = \theta_K \left[\sigma_{VA} \theta_{VA}^{-1} - \sigma_Y (\theta_{VA}^{-1} - 1) \right]$$

where σ_{LS} and σ_{LK} are the Allen partial elasticities of substitution. The remaining own and cross price elasticities follow similarly.

We contrast this production structure with one that allows complementarity of capital and skill, illustrated in Figure 2. The highest level of the nest is the same as previously, with the level of output indicated by equation (3). Following the primary factor branch of the nest, the value-added composite is now

$$(10) \quad VA = \alpha_{VA} \left[\phi_{VKL} (\delta_{VKL} VKL)^{-\rho_{VA}} + \phi_R (\delta_R R)^{-\rho_{VA}} + \phi_A (\delta_A A)^{-\rho_{VA}} \right]^{-\frac{1}{\rho_{VA}}}$$

where VKL is value added in capital, labour and skill. Also as before, the elasticity of substitution at this level is $\sigma_{VA} = 1/(1 + \rho_{VA})$. The capital-labour-skill component of value added, VKL is then:

$$(11) \quad VKL = \alpha_{VKL} \left[\phi_{KS} (\delta_{KS} KS)^{-\rho_{VKL}} + \phi_L (\delta_L L)^{-\rho_{VKL}} \right]^{-\frac{1}{\rho_{VKL}}}$$

where L is raw labour and KS is a capital-skill composite. The level-specific or branch elasticity of substitution is then $\sigma_{VKL} = 1/(1 + \rho_{VKL})$. Finally, there is an additional level that divides capital and skill:

²² The remaining parameters are derived from the GTAP Version 4 database for each region, detailed in McDougall et al. (1998a).

²³ For a single level system in which the elasticity of substitution is σ this collapses to $-\theta[\sigma(\theta_L^{-1} - 1)] = -(1 - \theta_L)\sigma$, consistent with the treatment by Hamermesh (1993).

$$(12) \quad VKS = \alpha_{VKS} \left[\phi_K (\delta_K K)^{-\rho_{VKS}} + \phi_S (\delta_S S)^{-\rho_{VKS}} \right]^{\frac{1}{\rho_{VKS}}}$$

where the branch elasticity of substitution at this lowest level is $\sigma_{VKS} = 1/(1 + \rho_{VKS})$.

In this case, the own price elasticity for capital takes the following form:

$$(13) \quad \eta_{KK} = -\theta_K \left[\sigma_{VKS} (\theta_K^{-1} - \theta_{VKS}^{-1}) + \sigma_{VKL} (\theta_{VKS}^{-1} - \theta_{VKL}^{-1}) + \sigma_{VA} (\theta_{VKL}^{-1} - \theta_{VA}^{-1}) + \sigma_Y (\theta_{VA}^{-1} - 1) \right]$$

where θ_K is the share of capital, θ_{VKS} the combined share of capital, θ_{VKL} the combined share of capital, skill and labour, and θ_{VA} is the share of value added in total cost. Since capital and skill are here treated symmetrically, the own price elasticity of demand for skill takes a corresponding form. And the cross elasticities between capital and skill and capital and labour are:

$$(14) \quad \eta_{KS} = \sigma_{KS} \theta_S = \theta_S \left[\sigma_{VKS} \theta_{VKS}^{-1} - \sigma_{VKL} (\theta_{VKS}^{-1} - \theta_{VKL}^{-1}) - \sigma_{VA} (\theta_{VKL}^{-1} - \theta_{VA}^{-1}) - \sigma_Y (\theta_{VA}^{-1} - 1) \right]$$

$$(15) \quad \eta_{KL} = \sigma_{KL} \theta_L = \theta_L \left[\sigma_{VKL} \theta_{VKL}^{-1} - \sigma_{VA} (\theta_{VKL}^{-1} - \theta_{VA}^{-1}) - \sigma_Y (\theta_{VA}^{-1} - 1) \right]$$

where, again, σ_{KS} and σ_{KL} are Allen partial elasticities of substitution. The remaining cross price elasticities follow similarly.

The branch elasticities in both the substitution and complementarity cases differ by industry and length of run by the same proportions as the “standard” set in the original GTAP database. The shorter length of run used here requires, however, that they be smaller than the standard values and so their choice has been informed both by the calibration exercise reported in Yang and Tyers (2000) and the contrasts between short and long run estimates by Morrison Paul and Siegel (2000). For the particular branch elasticities between capital labour and skill, we note the small short run elasticities between capital and labour reviewed by Rowthorn (1999a and b) but have opted for larger values from the studies reviewed by Hamermesh (1993) and the estimates of Krusell et al. (1997), as indicated in Tables 3 and 4. The implied own and cross price elasticities are then listed in Table 5. The parameters of the macro part of the model (those in the consumption and investment demand equations and in the real money demand equation) are listed in Table 6.

4. Simulating US “New Economy” Shocks

The results obtained by Tyers and Yang (2000) offer two alternative characterisations of technical change in the final two decades of the 20th century. First, if

technology is characterised following Kahn and Lim (1998) as embodying substitution between capital and skill, the principal technical change takes the form of skill enhancement. If it is characterised following Krusell et al. (1997) as embodying capital-skill complementarity, the implied technical change is capital enhancement. Most economy-wide modelling assumes the former while the preponderance of empirical evidence supports the latter. Our purpose here is to ask what difference it makes in a short run setting. To do this we note from Tyers and Yang (2000) that the change was the most rapid in the US. Moreover, the evidence of Oliner and Sichel (2000) indicates that it accelerated in the US in the latter half of the 1990s. We therefore focus on a technical change shock in the US alone.

The primary shock enhances capital in the manufacturing and services sectors of the US economy by an arbitrary five per cent. We combine this with a five per cent increase in real investment in the US. This is about the size of the increase in the annual growth rate of US real investment between the mid-1990s and the end of the decade. Our interest in this combination of shocks stems from the apparent association between the technology surge in the US and a simultaneous concentration of global investment there²⁴, both of which appear to have played key roles in the overall pattern of change in the global economy in recent years. We do not, and indeed cannot in a comparative static model, endogenise the change in the locational preferences of savers that took place in the 1990s and which favoured investment in the US. Both the technical change shock and the investment shock are therefore imposed exogenously.

Before we describe the scenarios in detail, it is useful to reflect briefly on their technical underpinnings. The model is simply a set of n non-linear simultaneous equations in $n+m$ variables. In such a system, only n variables can be endogenous. We must find values elsewhere for the remaining m exogenous variables. The software we use draws on the initial database for 1995 to derive initial values for the entire $n+m$ variables. Then, in effect, it transforms the equations so as to allow the selection of any n of these variables as endogenous. The remaining m variables are then either assumed to hold their database values or they can be subjected to exogenous shocks. This selection of variables as either endogenous or exogenous is what we refer to as the “closure”.

In a “normal” simulation, the change in investment would be endogenous and the investment premium factor $[(I + \pi)$ in equation 1] would be exogenous. But here we wish to

²⁴ See IMF (2000): Figure 1.2.

represent a change in the locational preferences of savers. We do this by imposing a change in the investment premium of sufficient magnitude that it yields the requisite five per cent rise in US investment. And this is achieved by the construction of the closure. We simply make the change in investment in the US exogenous and impose a five per cent shock to it while making the US investment premium endogenous. The technical changes are imposed as exogenous shocks to parameters that are already exogenous, namely to δ_s in equation (3) for the factor substitution case or δ_k in equation (10) for the capital-skill complementarity case. These are the only exogenous shocks imposed yet a great deal depends on the choice of which remaining variables will be exogenous.

First, in the short run physical capital is industry specific and fixed in quantity in all regions. The return on installed capital is therefore endogenous and it differs by sector. Investment behaviour (equation 1) is then directed by the aggregate return on all of a region's installed capital. Monetary policy is assumed to target the domestic CPI, P^C , in all regions except China, which maintains fixed nominal parity with the US dollar. This implies that nominal money supplies are endogenous in all regions and these are balanced by the exogeneity of P^C , which is held constant, in all regions except China and the nominal exchange rate, E , which is also held constant, in China. Monetary policy matters at this length of run because it sets the price level and hence, where the nominal wage is rigid, the real wage of unskilled workers.²⁵ In the EU, labour market regulation is assumed to deliver nominal wage changes to match the CPI, so that the real wage of unskilled workers is fixed. In Canada and Australasia, and in China, the nominal wage is assumed to adjust by half of any proportional change in the CPI ($\lambda=0.5$ in equation 2).²⁶ In these three regions the level of employment is therefore endogenous. On the other hand, in the US, Japan and other Asia, equation (2) is actually disabled to allow the nominal wage to adjust to clear the labour market and so keep employment fixed and the real wage of unskilled workers endogenous.

With this closure common to every case, four simulations are carried out. These are, first, assuming capital and skill are complements: (1) the imposition of a 3% capital

²⁵ Because savings are fully mobile internationally, monetary policy in one region has no direct effect on the domestic interest rate while ever the interest premium remains exogenous. Recall from equation (1) that current investment is allocated to regions where the rate of return on installed capital is high. This rate of return and the regional interest rate, which is formed originally in the global market for loanable funds, will generally be different in short run departures from the steady state of the type simulated.

²⁶ Recall that the CPI is fixed by monetary targeting in all regions except China, so the nominal wage and real wages are also fixed in Canada and Australasia. Only in China are there changes in both the nominal and real wages with the nominal wage change stemming from equation (2).

enhancement in the US alone and (2) the combination of a 3% capital enhancement with the observed 5% rise in US investment. The results from these experiments are displayed in Tables 7 and 8. Second, assuming capital and skill are substitutes, we simulate (1) the imposition of a 5% skill enhancement in the US alone, and (2) the combination of a 5% skill enhancement with the observed 5% rise in US investment. The results from these two experiments are displayed in Tables 9 and 10.

References:

- Abraham, K. and S. Taylor, "Firms' use of outside contractors: theory and evidence", *Journal of Labor Economics*, 14:394-424, 1996.
- Allen, R.G.D., *Mathematical Analysis for Economists*, London: Macmillan, 1938.
- Burfisher, M.E., S. Robinson and K.E. Thierfelder, "Wage Changes in a U.S.-Mexico Free Trade Area: Migration versus Stolper-Samuelson Effects", In J.F. Francois and C.R. Shiells, eds. *Modeling trade policy: Applied general equilibrium assessments in North American free trade*. Cambridge; New York and Melbourne: Cambridge University Press, 1994, pp 195-222.
- Davis, D.R., "Technology, unemployment and relative wages in a global economy", *European Economic Review*, 42: 1613-1633, 1998.
- Dixon, P.B., B.R. Parmenter, A.A. Powell and P.J. Wilcoxon, *Notes and Problems in Applied General Equilibrium Economics*, Amsterdam: North-Holland 1992.
- Fallon, P.R. and P.R.G. Layard (1975), "Capital-skill complementarity, income distribution and output accounting", *Journal of Political Economy*, 83(2): 279-301.
- Feenstra, R.C. and G.H. Hanson, 'Foreign Investment, Outsourcing, and Relative Wages', in Robert C. Feenstra, Gene M. Grossman, and Douglas A Irwin (eds), *The Political Economy of Trade Policy: Papers in Honor of Jagdish Bhagwati*, The MIT Press, Cambridge, Massachusetts, 1996.
- Goldin, C. and L.F. Katz, "The origins of capital-skill complementarity", *Quarterly Journal of Economics*, 113: 693-732, August 1998.
- Greenwood, J., Z. Hercowitz and P. Krusell (1997), "Long run implications of investment-specific technological change", *American Economic Review* 87: 342-362.
- _____ (2000), "The role of investment-specific technological change in the business cycle", *European Economic Review*, 44(1): 91-115.
- Griliches, Z. (1969), "Capital-skill complementarity", *Review of Economics and Statistics* 51(4):465-468.
- Hamermesh, D.S. (1993), *Labor Demand*, New Jersey: Princeton University Press.
- Haskel, J. and Y. Heden (1999), "Computers and the demand for skilled labour: industry and establishment level panel evidence for the UK", *Economic Journal*, 109: 68-79.
- Haskel, J. and M.J. Slaughter (1998), "Does the sector bias of skill-biased technical change explain changing skill differentials?" NBER Working Paper No. 6565.
- _____ (1999), "Trade, technology and U.K. wage inequality", Centre for Research of Globalisation and Labour Markets Working Paper No. 99/2, University of Nottingham.
- Hertel, T.W. (ed.), *Global Trade Analysis Using the GTAP Model*, New York: Cambridge University Press, 1997.

- Huff, K.M., K. Hanslow, T.W. Hertel and M.E. Tsigas, "GTAP behavioural parameters", Chapter 4 in T.W. Hertel (ed.) *op cit* 1997.
- IMF (2000), *World Economic Outlook*, Washington DC, May.
- Kahn, J.A. and J.-S. Lim, "Skilled labor augmenting technical progress in U.S. manufacturing", *Quarterly Journal of Economics*, 113(4): 1281-1308, 1998.
- Keller, W.J., *Tax Incidence: A General Equilibrium Approach*, Amsterdam: North Holland, 1980.
- Krusell, P., L.E. Ohanian, J.-V. Rios-Rull and G.L. Violante, "Capital-skill complementarity and inequality: a macroeconomic analysis", Research Department Staff Report 239, Federal Reserve Bank of Minneapolis, September 1997.
- Liu, J. N. Van Leeuwen, T.T. Vo, R. Tyers, and T.W. Hertel, "Disaggregating Labor Payments by Skill Level in GTAP", Technical Paper No.11, Center for Global Trade Analysis, Department of Agricultural Economics, Purdue University, West Lafayette, September 1988 (<http://www.agecon.purdue.edu/gtap/techpapr/tp-11.htm>)
- McDougall, R.A., A. Elbehri and T.P. Truong (eds.) *Global Trade, Assistance and Protection: The GTAP 4 Database*, Center for Global Trade Analysis, Purdue University, December 1998a.
- McDougall, R.A., B. Dimaranan and T.W. Hertel, "Behavioural parameters". Chapter 19 in R.A. McDougall, A. Elbehri and T.P. Truong (eds.) *Global Trade, Assistance and Protection: The GTAP 4 Database*, Center for Global Trade Analysis, Purdue University, December 1998b.
- Morrison Paul, C.J. and D.Siegel, "The impact of technology, trade and outsourcing on employment and labor composition", Centre for Research on Globalisation and Labour Markets Working Paper No. 2000/10, 2000.
- Oliner, S.D. and D.E. Sichel (2000), "The resurgence of growth in the late 1990s: is information technology the story?" US Federal Reserve Board, Washington DC, May.
- Rowthorn, R., "Unemployment, wage bargaining and capital-labour substitution", *Cambridge Journal of Economics* 23: 413-425, 1999a.
- _____, "Unemployment, capital-labour substitution and economic growth", IMF Working Paper WP/99/43, International Monetary Fund, Washington DC, March 1999b.
- Sachs, Jeffrey D. and Howard J. Shatz, "Trade and Jobs in U.S. Manufacturing", *Brookings Papers on Economic Activity*, No. 1, pp. 1-84, 1994.
- Shoven, J.B. and J. Whalley, *Applying General Equilibrium*, Cambridge: Cambridge University Press 1992.
- Tyers, R. and Yang, Y. (2000), 'Capital-Skill Complementarity and Wage Outcomes Following Technical Change in a Global Model', *Oxford Review of Economic Policy*, 16(3): 23-41.
- Vo, T.T. and R. Tyers (1995), "Splitting labour by occupation in GTAP: sources and assumptions", Project Paper No.5, Trade and Wage Dispersion Project, World Bank and ANU, September 1995 (most of which later became part of Liu et al. *op cit*).
- Whelan, K. (2000), "Computers, obsolescence and productivity", Division of Research and Statistics, Federal Reserve Board, Washington DC, February.
- Wood, A. (1994), *North-South Trade, Employment and Inequality*, Clarendon Press, Oxford.
- Yang, Y. and R. Tyers (2000), "China's post-crisis policy dilemma: multi-sectoral comparative static macroeconomics", Working Papers in Economics and Econometrics No. 384, Australian National University, June 2000, 35pp, presented at the Third Annual Conference on Global Economic Analysis, Melbourne, 27-30 June 2000. (<http://ecocomm.anu.edu.au/departments/economics/staff/tyers/tyers.html>)

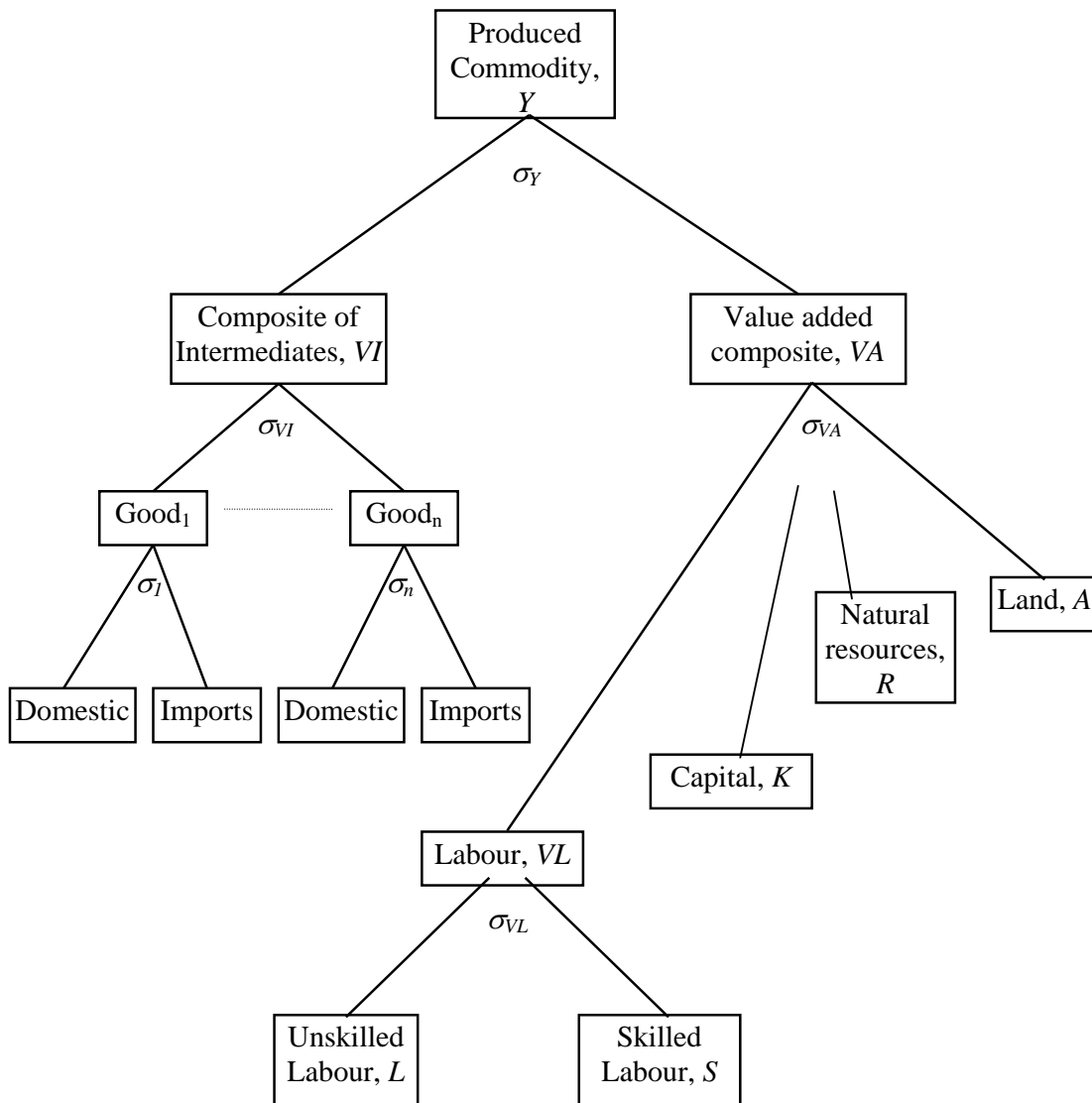


Figure 1: Original factor demand nest

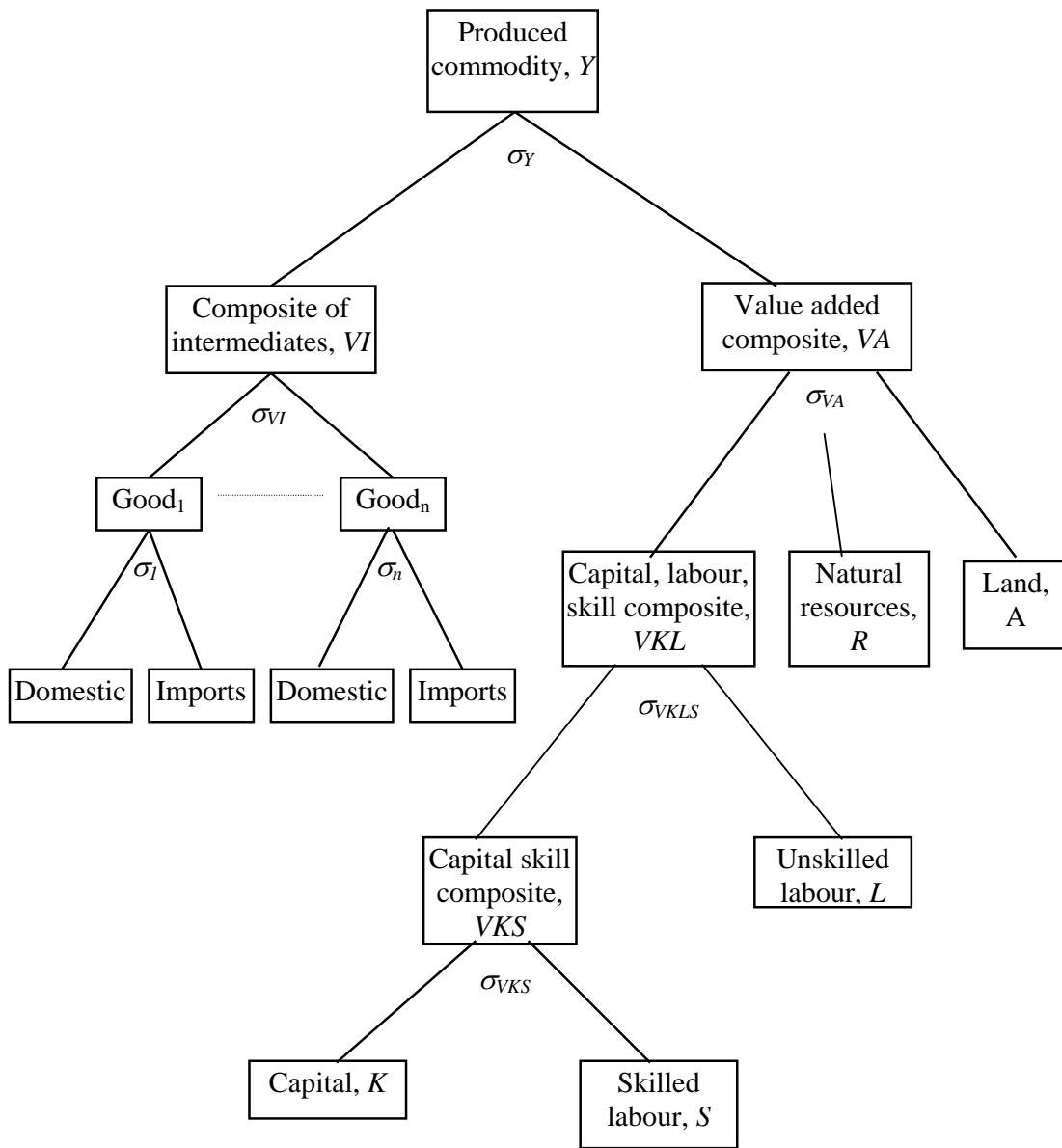


Figure 2: Nest with capital-skill complementarity

Table 1: Model structure

Regions	Share of 1995 world GDP ^f
1. Rapidly growing Asia ^a	5.1
2. Japan	18.0
3. China ^b	2.5
4. European Union ^c	29.0
5. United States	25.2
6. Canada and Australasia	3.5
7. Rest of world	16.8
Primary factors	
1. Agricultural land	
2. Natural resources	
3. Skill	
4. Labour	
5. Physical capital	
Sectors ^e	
1. All agriculture	
2. Mining and energy (coal, oil, gas and other minerals)	
3. Skill-intensive manufacturing (petroleum, paper, chemicals, processed minerals, metals, motor vehicles and other transport equipment, electronic equipment and other machinery and equipment)	
4. Labour-intensive manufacturing (textiles, apparel, leather and wood products, metal products, other manufactures)	
5. Skill-intensive services (electricity, gas, water, financial services and public administration)	
6. Labour-intensive services (construction, retail and wholesale trade, dwellings)	

a Korea (Rep.), Indonesia, Philippines, Malaysia, Singapore, Thailand, Vietnam, Hong Kong and Taiwan.

b China excludes Hong Kong and Taiwan.

c The European Union of 15.

d These are aggregates of the 50 sector GTAP Version 4 database. See McDougall et al. (1998a).

e Share of 1995 GDP in US\$ measured at market prices and exchange rates.

Table 2: Short Run Elasticities of substitution in final and intermediate product demand^a

Sector	In product demand, between domestic and imported	In import demand, between regions of origin
Agriculture	1.8	3.4
Mining	2.0	4.1
Manufacturing: labour intensive	2.7	5.8
skill intensive	1.6	3.3
Services: labour intensive	0.9	1.9
skill intensive	1.0	1.9

a These are group-specific weighted averages across the 50 industries defined in the database. The structure of intermediate demand is as indicated in Figure 1. The CDE parameters governing substitution in final demand are discussed in McDougall et al. (1998b).

Source: GTAP Database Version 4.1. See McDougall et al. (1998a).

Table 3: Branch elasticities of substitution in the case where all factors are substitutes

Sector	In production between intermediates and primary factors, σ_Y	In value added, between labour-skill, capital, resources and land, σ_{VA}	Between labour and skill, σ_{VLS}
Agriculture	0.0	0.1	0.4
Mining	0.0	0.1	0.4
Manufacturing: labour intensive	0.0	0.6	1.5
skill intensive	0.0	0.6	1.5
Services: labour intensive	0.0	0.8	1.8
skill intensive	0.0	0.6	1.5

Source: The value added branch elasticities are larger than the standard GTAP factor substitution elasticities, to reflect the long run as explained in the text. See Table 19.2 of McDougall et al. (1998b).

Table 4: Branch elasticities of substitution in the case where capital and skill are complements

Sector	In production between intermediates and primary factors, σ_Y	In value added, between capital-labour-skill, resources and land, σ_{VA}	Between capital-skill and labour, σ_{VKL}	Between capital and skill, σ_{VKS}
Agriculture	0.0	0.1	0.3	0.2
Mining	0.0	0.1	0.3	0.2
Manufacturing: labour intensive	0.0	0.6	1.4	0.4
skill intensive	0.0	0.6	1.6	0.4
Services: labour intensive	0.0	0.8	2.0	0.5
skill intensive	0.0	0.6	1.6	0.4

Source: The value added branch elasticities are larger than the standard GTAP factor substitution elasticities, to reflect the long run as explained in the text. See Table 19.2 of McDougall et al. (1998b).

Table 5: Implied Short Run Elasticities of Primary Factor Demand in the United States^a

Sector:	Own price			Cross price					
	Labour, L	Skill, S	Capital, K	K-L	L-K	K-S	S-K	S-L	L-S
<i>All factors substitutes</i>									
Agriculture	-0.09	-0.38	-0.06	0.03	0.04	0.00	0.04	0.31	0.02
Mining	-0.17	-0.30	-0.06	0.02	0.04	0.01	0.04	0.23	0.10
Labour intensive mfg	-0.54	-1.20	-0.36	0.27	0.24	0.09	0.24	0.96	0.30
Skill-intensive mfg	-0.75	-0.98	-0.37	0.22	0.23	0.15	0.23	0.75	0.52
Labour intensive services	-0.65	-1.48	-0.47	0.37	0.33	0.10	0.33	1.15	0.32
Skill intensive services	-0.90	-0.77	-0.43	0.20	0.17	0.24	0.17	0.60	0.73
<i>Capital and skill complements</i>									
Agriculture	-0.19	-0.10	-0.16	0.11	0.13	0.00	-0.06	0.11	0.01
Mining	-0.24	-0.10	-0.12	0.06	0.15	0.00	-0.02	0.06	0.03
Labour intensive mfg	-0.66	-0.40	-0.49	0.54	0.49	-0.05	-0.14	0.54	0.17
Skill-intensive mfg	-0.76	-0.36	-0.38	0.44	0.46	-0.06	-0.08	0.44	0.30
Labour intensive services	-0.75	-0.46	-0.59	0.65	0.58	-0.06	-0.19	0.65	0.18
Skill intensive services	-0.77	-0.35	-0.33	0.38	0.32	-0.05	-0.03	0.38	0.45

^a These are conditional elasticities for the U.S. Those for other regions will differ as factor shares in total cost differ.

Source: Branch elasticities in Tables 3 and 4 and factor and input shares for the United States in 1995, drawn from the GTAP database (Mcdougall et al. 1998a).

Table 6: Key Macroeconomic Parameters in Short Run Analysis^a

Elasticity of	
Real consumption to the interest rate, δ	-0.10
Real consumption to disposable income, μ^b	0.65–0.80
Investment: $(K+I)/K$ to gross interest ratio $(I+r)/(I+r^e)$, ε	-0.10
Real money demand to income, η	0.50
Real money demand to the interest rate, ϕ	-0.10

a In this preliminary application, most of these parameter values are common to all regions.

b RG Asia 0.7, Japan 0.75, China 0.65, USA, EU, Canada/Australasia 0.8, rest of world 0.75

Sources: Indicative estimates. See Yang and Tyers (2000).

Table 7: The simulated short run global effects of a 3% capital enhancement alone in the US (capital and skill complementary)^a

Change in:	USA	EU	Canada Aust NZ	Japan	China	Rapidly Growing Asia
Nominal exchange rate(US\$/●), E_i (%)	0.0	3.0	2.9	3.0	0.0*	2.6
Domestic CPI, P^C (%)	0.0*	0.0*	0.0*	0.0*	2.4	0.0*
Domestic GDP deflator, P^Y (%)	-0.3	0.1	0.3	0.0	2.3	0.0
Nominal money supply, M_S (%)	0.2	0.1	0.5	0.1	2.6	0.1
Real effective exchange rate ^b , e_i^R (%)	-3.3	0.6	2.1	0.9	-0.1	0.4
Real exchange rate against USA, e_{ij}^R (%)	0.0	3.4	3.5	3.4	2.6	3.0
Terms of trade ^c (%)	-2.5	0.2	1.3	0.4	-0.2	0.1
Global interest rate, r^w	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
Investment premium, π (%)	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*
Home interest rate, r (%)	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
Return on installed capital ^d , r^c (%)	-2.1	0.2	1.0	0.0	0.3	0.1
Real domestic investment, I (%)	-2.4	1.0	2.0	0.5	0.5	0.4
Real consumption, C (%)	0.6	0.1	0.6	0.1	0.2	0.1
Balance of trade, $X-M$ (US\$b)	36.5	-15.4	-2.2	-6.8	1.1	-2.8
<i>Real gross sectoral output (%)</i>						
Agriculture	0.8	0.1	0.0	0.0	0.4	0.0
Mining	0.5	0.2	0.2	0.3	0.3	0.2
Manufacturing: labour-intensive	1.4	0.0	-0.3	-0.1	0.5	-0.1
skill-intensive	1.8	-0.2	-0.6	-0.2	0.3	-0.2
Services: labour-intensive	0.7	0.2	0.5	0.1	0.4	0.1
skill-intensive	0.9	0.0	0.2	0.0	0.3	0.0
Real GDP, Y (%)	1.0	0.0	0.2	0.0	0.4	0.0
<i>Unskilled wage and employment</i>						
Nominal (unskilled) wage, W (%):	0.2	0.0*	0.0*	0.1	1.2*	0.0
Production real wage, $w=W/P^Y$ (%):	0.4	-0.1	-0.3	0.0	-1.1	-0.1
Employment, L^D (%)	0.0*	0.1	0.3	0.0*	0.9	0.0*
<i>Unit factor rewards CPI deflated (%)</i>						
Labour	0.2	0.0	0.0	0.1	-1.2	0.0
Skill	3.9	0.0	0.4	0.1	-0.1	0.0
Capital	-1.4	0.1	0.6	0.0	0.1	0.0
Land	11.0	0.4	0.2	-0.2	1.8	0.4
Natural resources	11.7	2.2	3.6	0.3	4.9	1.9

a All variables shown are endogenous, except for the CPI change in all regions but China, the US-China nominal exchange rate, the level of real investment in the US, the investment premia on interest rates in the other regions, the nominal wage of low skill workers in the EU, CANZ and China and the levels of employment in the US, Japan and RG Asia. The exogenous changes are marked with an asterisk (*).

b Change in the trade weighted average value of $e_{ij}^R=(E_i/E_j) P_i^Y/P_j^Y$ over regions j .

c Change in the value of exports at endogenous prices, weighted by fixed 1995 (base period) export volumes, divided by the value of imports, weighted by fixed 1995 import volumes.

d Per cent change in payments to capital less the per cent change in the capital goods price index.

Source: Model simulations discussed in the text.

Table 8: The simulated short run global effects of a 3% capital enhancement combined with a 5% investment increase in the US (capital and skill complementary)^a

Change in:	USA	EU	Canada Aust, NZ	Japan	China	Rapidly Growing Asia
Nominal exchange rate(US\$/●), E_i (%)	0.0	-3.6	-2.5	-3.9	0.0*	-2.9
Domestic CPI, P^C (%)	0.0*	0.0*	0.0*	0.0*	-2.6	0.0*
Domestic GDP deflator, P^Y (%)	0.3	-0.1	-0.1	-0.1	-2.5	-0.1
Nominal money supply, M_S (%)	1.3	-0.3	-0.2	-0.2	-2.8	-0.2
Real effective exchange rate ^b , e_i^R (%)	3.7	-1.3	-1.2	-1.8	0.3	-0.4
Real exchange rate against USA, e_{ij}^R (%)	0.0	-4.0	-2.9	-4.3	-2.8	-3.2
Terms of trade ^c (%)	2.6	-0.5	-0.3	-1.5	0.3	-0.1
Global interest rate, r^w	0.7	0.7	0.7	0.7	0.7	0.7
Investment premium, π (%)	-5.1	0.0*	0.0*	0.0*	0.0*	0.0*
Home interest rate, r (%)	-4.4	0.7	0.7	0.7	0.7	0.7
Return on installed capital ^d , r^c (%)	-0.9	-0.5	-0.3	-0.2	-0.5	-0.1
Real domestic investment, I (%)	5.0*	-2.0	-1.5	-1.2	-0.9	-0.7
Real consumption, C (%)	1.6	-0.3	-0.3	-0.2	-0.4	-0.1
Balance of trade, $X-M$ (US\$b)	-59.5	27.5	2.2	13.8	-0.5	4.6
<i>Real gross sectoral output (%)</i>						
Agriculture	-0.4	0.1	0.0	0.3	-0.4	0.1
Mining	-0.2	0.2	0.1	0.5	-0.1	0.2
Manufacturing: labour-intensive	0.4	-0.1	0.0	0.1	-0.6	0.1
skill-intensive	0.2	0.2	0.3	0.4	-0.6	0.1
Services: labour-intensive	1.8	-0.4	-0.4	-0.3	-0.7	-0.2
skill-intensive	0.9	-0.1	-0.1	0.0	-0.5	0.0
Real GDP, Y (%)	1.0	-0.2	-0.1	0.0	-0.5	0.0
<i>Unskilled wage and employment</i>						
Nominal (unskilled) wage, W (%):	1.2	0.0*	0.0*	-0.2	-1.3*	-0.2
Production real wage, $w=W/P^Y$ (%):	0.9	0.1	0.1	-0.1	1.3	-0.1
Employment, L^D (%)	0.0*	-0.2	-0.3	0.0*	-1.2	0.0*
<i>Unit factor rewards CPI deflated (%)</i>						
Labour	1.2	0.0	0.0	-0.2	1.3	-0.2
Skill	4.7	-0.3	-0.3	-0.3	-0.4	-0.2
Capital	-1.0	-0.3	-0.2	0.0	-0.4	-0.2
Land	-3.5	0.8	0.2	2.4	-2.0	1.0
Natural resources	-1.6	3.4	2.5	3.1	-1.2	1.9

a All variables shown are endogenous, except for the CPI change in all regions but China, the US-China nominal exchange rate, the level of real investment in the US, the investment premia on interest rates in the other regions, the nominal wage of low skill workers in the EU, CANZ and China and the levels of employment in the US, Japan and RG Asia. The exogenous changes are marked with an asterisk (*).

b Change in the trade weighted average value of $e_{ij}^R=(E_i/E_j) P_i^Y/P_j^Y$ over regions j .

c Change in the value of exports at endogenous prices, weighted by fixed 1995 (base period) export volumes, divided by the value of imports, weighted by fixed 1995 import volumes.

d Per cent change in payments to capital less the per cent change in the capital goods price index.

Source: Model simulations discussed in the text.

Table 9: The simulated short run global effects of a 5% skill enhancement alone in the US (capital and skill substitutes)^a

Change in:	USA	EU	Canada Aust, NZ	Japan	China	Rapidly Growing Asia
Nominal exchange rate(US\$/●), E_i (%)	0.0	-1.4	-0.2	-1.4	0.0*	-0.8
Domestic CPI, P^C (%)	0.0*	0.0*	0.0*	0.0*	-0.8	0.0*
Domestic GDP deflator, P^Y (%)	0.1	-0.1	0.1	-0.1	-0.8	-0.1
Nominal money supply, M_S (%)	0.7	-0.2	0.1	-0.1	-1.0	-0.1
Real effective exchange rate ^b , e_i^R (%)	1.0	-1.0	0.3	-0.9	0.0	-0.1
Real exchange rate against USA, e_{ij}^R (%)	0.0	-1.6	-0.2	-1.6	-0.9	-1.0
Terms of trade ^c (%)	0.7	-0.4	0.5	-1.0	0.0	-0.1
Global interest rate, r^w	0.4	0.4	0.4	0.4	0.4	0.4
Investment premium, π (%)	0.0*	0.0*	0.0*	0.0*	0.0*	0.0*
Home interest rate, r (%)	0.4	0.4	0.4	0.4	0.4	0.4
Return on installed capital ^d , r^c (%)	2.6	-0.5	0.3	-0.1	-0.5	0.0
Real domestic investment, I (%)	3.0	-1.5	-0.1	-0.6	-0.6	-0.3
Real consumption, C (%)	1.5	-0.3	0.2	-0.1	-0.2	-0.1
Balance of trade, $X-M$ (US\$b)	-31.1	20.6	0.2	6.8	0.7	2.0
<i>Real gross sectoral output (%)</i>						
Agriculture	0.1	0.1	0.0	0.1	-0.1	0.1
Mining	0.1	0.2	0.1	0.4	0.1	0.2
Manufacturing: labour-intensive	0.6	0.0	-0.1	0.0	-0.1	0.1
skill-intensive	0.8	0.1	-0.2	0.2	-0.2	0.0
Services: labour-intensive	1.4	-0.3	0.0	-0.1	-0.3	-0.1
skill-intensive	1.6	-0.1	0.0	0.0	-0.2	0.0
Real GDP, Y (%)	1.3	-0.1	0.0	0.0	-0.2	0.0
<i>Unskilled wage and employment</i>						
Nominal (unskilled) wage, W (%):	0.3	0.0*	0.0*	-0.2	-0.4*	-0.3
Production real wage, $w=W/P^Y$ (%):	0.2	0.1	-0.1	-0.1	0.4	-0.2
Employment, L^D (%)	0.0*	-0.2	0.0	0.0*	-0.4	0.0*
<i>Unit factor rewards CPI deflated (%)</i>						
Labour	0.3	0.0	0.0	-0.2	0.4	-0.3
Skill	1.8	-0.2	0.0	-0.2	-0.1	-0.3
Capital	2.1	-0.3	0.2	0.0	-0.4	-0.1
Land	2.2	1.8	-0.2	2.3	-1.0	1.1
Natural resources	6.5	5.9	5.0	3.6	3.6	3.4

a All variables shown are endogenous, except for the CPI change in all regions but China, the US-China nominal exchange rate, the level of real investment in the US, the investment premia on interest rates in the other regions, the nominal wage of low skill workers in the EU, CANZ and China and the levels of employment in the US, Japan and RG Asia. The exogenous changes are marked with an asterisk (*).

b Change in the trade weighted average value of $e_{ij}^R = (E_i/E_j) P_i^Y/P_j^Y$ over regions j .

c Change in the value of exports at endogenous prices, weighted by fixed 1995 (base period) export volumes, divided by the value of imports, weighted by fixed 1995 import volumes.

d Per cent change in payments to capital less the per cent change in the capital goods price index.

Source: Model simulations discussed in the text.

Table 10: The simulated short run global effects of a 5% skill enhancement combined with a 5% investment increase in the US (capital and skill substitutes)^a

Change in:	USA	EU	Canada Aust, NZ	Japan	China	Rapidly Growing Asia
Nominal exchange rate(US\$/●), E_i (%)	0.0	-2.9	-1.6	-3.0	0.0*	-2.1
Domestic CPI, P^C (%)	0.0*	0.0*	0.0*	0.0*	-2.2	0.0*
Domestic GDP deflator, P^Y (%)	0.2	-0.2	0.0	-0.1	-2.1	-0.1
Nominal money supply, M_S (%)	1.0	-0.3	-0.1	-0.2	-2.4	-0.1
Real effective exchange rate ^b , e_i^R (%)	2.7	-1.5	-0.5	-1.4	-0.1	-0.2
Real exchange rate against USA, e_{ij}^R (%)	0.0	-3.3	-1.8	-3.3	-2.4	-2.4
Terms of trade ^c (%)	2.0	-0.5	0.1	-1.4	0.0	-0.1
Global interest rate, r^w	0.6	0.6	0.6	0.6	0.6	0.6
Investment premium, π (%)	-1.4	0.0*	0.0*	0.0*	0.0*	0.0*
Home interest rate, r (%)	-0.8	0.6	0.6	0.6	0.6	0.6
Return on installed capital ^d , r^c (%)	2.9	-0.8	-0.1	-0.1	-0.8	-0.1
Real domestic investment, I (%)	5.0*	-2.3	-1.0	-1.0	-1.1	-0.6
Real consumption, C (%)	1.7	-0.4	0.0	-0.1	-0.4	-0.1
Balance of trade, $X-M$ (US\$b)	-53.2	31.4	1.5	10.6	0.8	3.5
<i>Real gross sectoral output (%)</i>						
Agriculture	-0.1	0.1	0.0	0.1	-0.2	0.0
Mining	0.1	0.2	0.1	0.5	0.1	0.2
Manufacturing: labour-intensive	0.4	0.0	0.0	0.1	-0.2	0.1
skill-intensive	0.4	0.2	0.1	0.3	-0.3	0.1
Services: labour-intensive	1.7	-0.4	-0.2	-0.2	-0.6	-0.1
skill-intensive	1.5	-0.1	-0.1	0.0	-0.4	0.0
Real GDP, Y (%)	1.3	-0.2	-0.1	0.0	-0.4	0.0
<i>Unskilled wage and employment</i>						
Nominal (unskilled) wage, W (%):	0.6	0.0*	0.0*	-0.3	-1.1*	-0.3
Production real wage, $w=W/P^Y$ (%):	0.4	0.2	0.0	-0.2	1.1	-0.2
Employment, L^D (%)	0.0*	-0.2	-0.1	0.0*	-0.8	0.0*
<i>Unit factor rewards CPI deflated (%)</i>						
Labour	0.6	0.0	0.0	-0.3	1.1	-0.3
Skill	2.0	-0.2	-0.1	-0.3	0.1	-0.3
Capital	2.1	-0.4	0.0	0.0	-0.7	-0.1
Land	-2.0	1.8	-0.3	2.7	-2.4	1.0
Natural resources	3.0	6.1	4.8	4.1	2.2	3.3

a All variables shown are endogenous, except for the CPI change in all regions but China, the US-China nominal exchange rate, the level of real investment in the US, the investment premia on interest rates in the other regions, the nominal wage of low skill workers in the EU, CANZ and China and the levels of employment in the US, Japan and RG Asia. The exogenous changes are marked with an asterisk (*).

b Change in the trade weighted average value of $e_{ij}^R = (E_i/E_j) P_i^Y/P_j^Y$ over regions j .

c Change in the value of exports at endogenous prices, weighted by fixed 1995 (base period) export volumes, divided by the value of imports, weighted by fixed 1995 import volumes.

d Per cent change in payments to capital less the per cent change in the capital goods price index.

Source: Model simulations discussed in the text.