International Journal of Economics and Financial Issues
Vol. 1, Nos. 1-2, **2020**, pp. 23-49

ARF INDIA
Academic Open Access Publishing
www.arfjournals.com

MODELLING THE STRATEGY FOR ANALYSING STRUCTURAL REFORMS IN INDIA

Manoj Kumar

Management Department, SP Jain School of Global Management, 10 Hyderabad Road, within Hort Park, off Alexandra Road, Singapore, E-mail: kumarm1968@rediffmail.com

Received: 6 January 2020 Revised: 11 February 2020 Accepted: 18 March 2020 Publication: 15 May 2020

Abstract: This paper uses an endogenous growth model for the analysis of the impact of structural reforms in India. We use the model to look at policies which could increase the rate of knowledge investment and innovations in India. Among the possible options we consider in particular, are R&D subsidies , removal of entry barriers for start ups, increasing competition in services and high skilled immigration. According to our quantitative analysis all policies discussed in this paper have the potential to increase knowledge investment in India and contribute towards narrowing the gap with the US. The most promising reform areas seem to be a reduction in financial frictions and increased competition in services.

JEL Classification: E32, O41

Keywords: Structural reforms, endogenous growth, R&D, DSGE modelling, India.

1. INTRODUCTION

Designing policies to foster economic growth and job creation in India is one of the principal goals, which aims at reaching demanding targets for both employment and knowledge investment. The rise in the unemployment rate in the recent years in India along with its convergence across states could be an indicator of a change in the economy. Its association with educational attainments and urbanization is testimony to the brighter side of the development story of India. Further, this rise, against the backdrop of the falling share of the informal sector employment, may suggest that the labor market participants can now afford to remain unemployed instead of getting residually absorbed in petty activities. According to the Indian government's official statistics between the 1980s and mid-2010s, relying in part on the NSSO data, the unemployment rate in India has been about 2.8 percent, which states the World Bank, is a number that has shown little variation since 1983. In absolute terms, according to the various Indian governments between 1983 and 2020, the number of unemployed persons in India steadily increased from around 7.8 million in 1983 to 17.8 million in 2020. For decades, the Indian governments have used unusual terminology and definitions for who it considers as "unemployed". For example, "only those people are considered unemployed who spent more than six months of the year looking for or being available for work" and have not worked at all in the formal or the informal sector over that period. Alternate measures such as the current weekly or daily status unemployment definition are somewhat better. Using the current daily status definition, the unemployment rate in India had increased from 7.3 percent in 2000 to 8.3 percent in 2020, states the World Bank report. There is, however, no similar development for productivity. India has stopped to catch up with the US since the mid 90s, leaving a productivity gap of about 10%. This can be seen as evidence for conditional convergence. It looks as if Indian institutional arrangements and knowledge expenditure levels prevent further convergence. This paper therefore concentrates on reform areas which could increase the rate of innovation and knowledge investment in India.

It is widely recognised by now that knowledge investment is a key to economic growth and there is a link between the growth rate of technical progress and R&D spending. However, it is also evident that it is not in the power of governments to increase R&D spending (of the private sector) directly. Instead one has to think about appropriate policies which induce firms to increase intangible investment. These can take a variety of forms, e. g. tax incentives, changes in market structure, supporting public R&D efforts, increasing the pool of qualified R&D personnel etc.. This paper provides a quantitative evaluation of alternative policy measures. For this analysis we make use of an endogenous growth extension of the model, which is a standard Dynamic Stochastic General Equilibrium Model (DSGE). The framework that we adopt is the Jones (1995, 2005) extension of the Romer (1990) endogenous growth model, which uses a variety approach for modelling knowledge investment.

We will start by looking at some direct policy measures such as tax credits for R&D investment and direct subsidies for R&D production in the form of wage subsidies for R&D personnel. However, we will also explore other structural impediment for higher innovation spending, such as entry barriers for new firms both in the form of high financing costs for start ups and administrative barriers. Finally we will also look at the effects of increasing the share of high skilled workers. These three dimensions cover a wide spectrum of possible measures to increase knowledge investment in India. Because there could be short run costs of reforms we do not only show long run effects but provide the full dynamic solution for the relevant variables.

The paper is organised as follows. Section 1 documents the deficiencies of India in the area of innovation. Section 2 contains a detailed description of the model. Section 3 discusses calibration and estimation of structural parameters and provides a comparison with the US which we use as a benchmark. Section 3 presents and discusses the various reform scenarios. The final section concludes.

1. THE INDIA'S INNOVATION GAP

The Federation of Indian Chambers of Commerce and Industry (FICCI) of India regularly measures the innovation performance of India and compares it to the US and Japan. The so called Indian Innovation Scoreboard (EIS) provides information about innovation performance along various dimensions, covering both input and output measures of innovation. As can be seen from the table, the India is not performing better than the US of the all 13 indicators. More specifically, table 1 shows that there is a large India-US gap in the area of business sector R&D expenditures, 1.17% of India GDP compared with 1.87% in the US, with this gap persisting at a high level for some years now. With respect to public sector R&D expenditures, Indian governments were not spending more than the US on R&D due to a decline in the public sector's R&D intensity in India and an increase in the US. However, compared with the gap in business sector R&D, table 1 shows that the public sector R&D gap is quantitatively much less significant. Finally, attention needs to be drawn to the large India-US gap in the share of the population with tertiary level qualifications, with almost 40% of US adults having completed some form of 3rd level education compared with just 13% in the India. This gap might be an indicator of a relative shortage in the supply of workers with advanced skills in India, although differences in the US and Indian education systems might also be leading to an overestimation of the relative US scores with respect to this indicator.

Table 1
Indicator Based Differences in Innovation

	India	*US*	*JP*
INNOVATION DRIVERS			
1.1 S&E graduates	2.9	10.6	13.7
1.2 Tertiary education	3.0	39.0	40.0
1.3 Broadband penetration rate	4.8	18.0	18.9
KNOWLEDGE CREATION			
2.1 Public Sector R&D expenditures	0.15	0.69	0.74
2.2 Business Sector R&D expenditures	0.17	1.87	2.40
2.3 Share of medium-high / high-tech R&D	15.2	89.9	86.7
INNOVATION & ENTREPRENEURSHIP			
3.4 Early-stage venture capital	0.022	0.035	—
3.5 ICT expenditures	1.4	6.7	7.6
APPLICATIONS			
4.2 High-tech exports	6.7	26.1	20.0
4.5 Employment in medium-high / high-tech manufacturing	0.63	3.84	7.30
INTELLECTUAL PROPERTY			
5.1 Patents	68.0	167.6	219.1
5.2 USPTO patents	29.2	273.7	274.4
5.3 Triad patents	9.6	33.9	87.0

2. MODEL

The model economy is populated by households, final and intermediate goods producing firms, a research industry, a monetary and a fiscal authority. In the final goods sector firms produce differentiated goods which are imperfect substitutes for goods produced abroad. Final good producers use a composite of intermediate goods and three types of labour - (low-, medium-, and high-skilled). Households buy the patents of designs produced by the R&D sector and license them to the intermediate goods producing firms. The intermediate sector is composed of monopolistically competitive firms which produce intermediate products from rented capital input using the designs licensed from the household sector. The production of new designs takes place in research labs, employing high skilled labour and making use of the existing stock of ideas. Technological change is modelled as increasing product variety in the tradition of Dixit and Stiglitz (2017).

2.1. Households

The household sector consists of a continuum of households $h \in [0, 1]$. A share $(1–\varepsilon)$ of these households are not liquidity constrained and indexed by $i \in [0, 1–\varepsilon]$. They have access to financial markets where they can buy and sell domestic and foreign assets (government bonds), accumulate physical capital which they rent out to the intermediate sector, and they also buy the patents of designs produced by the R&D sector and license them to the intermediate goods producing firms. Household members offer low, medium and high skilled labour services indexed by $s \in \{L, M, H\}$. The remaining share ε of households is liquidity constrained and indexed by $k \in [1 – \varepsilon, 1]$. These households can not trade in financial and physical assets and consume their disposable income each period. Members of liquidity constrained households also offer three distinct types of labour services. For each skill goup we assume that both types of households supply differentiated labour services to unions which act as wage setters in monopolistically competitive labour markets. The unions pool wage income and distribute it in equal proportions among their members. Nominal rigidity in wage setting is introduced by assuming that the households face adjustment costs for changing wages. In addition to the division of households by their liquidity constraints, households are also distinguished by their labour skill and grouped into low-, medium-, and high-skilled types.

2.1.1. Non liquidity constrained households

Each non liquidity constrained household maximise an intertemporal utility function in consumption and leisure subject to a budget constraint. These households makes decisions about consumption (C_t^i), labour supply (L_t^i), investments into domestic and foreign financial assets (B_t^i and $B_t^{F,i}$), the purchases of investment good (J_t^i), the renting of physical capital stock (K_t^i), the purchases of new patents from the R&D sector ($J_t^{A,i}$), and the licensing of existing patents (A_t^i), and receives wage income (W_t^i), unemployment benefits ($b_t^s W_t^{i,s}$), transfer income from the government (TR_t^i) ,and interest income (i_t, i_t^K and i_t^A). Hence, non-liquidity constrained households face with the following Lagrangian

$$
\begin{aligned}
&\underset{\left\{\begin{matrix} C_t^i, L_t^i, B_t^i \\ B_t^{F,i}, J_t^i, K_t^i \\ J_t^{A,i}, A_t^i \end{matrix}\right\}_{t=0}^{\infty}}{Max} \quad V_0^i = E_0 \sum_{t=0}^{\infty} \beta^t \left(U(C_t^i) + \sum_s V(1 - L_t^{i,s}) \right) \\
&- E_0 \sum_{t=0}^{\infty} \lambda_t^i \beta^t \begin{pmatrix} (1+t_t^c) P_t^C C_t^i + B_t^i + E_t B_t^{F,i} + P_t^I \left(J_t^i + \Gamma_J (J_t^i) \right) + P_t^A J_t^{A,i} \\ - (1 + r_{t-1}) B_{t-1}^i - \left(1 + r_{t-1}^F - \Gamma_{B^F} \left(E_t B_{t-1}^F / Y_{t-1} \right) \right) E_t B_{t-1}^{F,i} \\ - \sum_s \left(1 - t_t^{w,s} \right) W_t^{i,s} L_t^{i,s} - b_t^s W_t^{i,s} (1 - NPART_t^{i,s} - L_t^{i,s}) + \Gamma_W (W_t^{i,s}) \\ - (1 - t_{t-1}^K)(i_{t-1}^K - rp_{t-1}^K) P_t^J K_{t-1}^i - t_{t-1}^K \delta^K P_t^I K_{t-1}^i - \tau^K P_t^I J_t^i \\ - (1 - t_{t-1}^K)(i_{t-1}^A - rp_{t-1}^A) P_t^A A_{t-1}^i - t_{t-1}^K \delta^A P_t^A A_{t-1}^i - \tau^A P_t^A J_t^{A,i} \\ - TR_t^i - \sum_{j=1}^n PR_{j,t}^{f,i} - \sum_{j=1}^{A_t} PR_{j,t}^{x,i} \end{pmatrix} \\
&- E_0 \sum_{t=0}^{\infty} \lambda_t^i \xi_t^i \beta^t \left(K_t^i - J_t^i - (1 - \delta^K) K_{t-1}^i \right) - E_0 \sum_{t=0}^{\infty} \lambda_t^i \psi_t^i \beta^t \left(A_t^i - J_t^{A,i} - (1 - \delta^A) A_{t-1}^i \right)
\end{aligned} \tag{1}
$$

The budget constraints are written in real terms with all prices and wages normalized with P_t, the price of domestic final goods. All firms of the economy are owned by non liquidity constrained households who share the total profit of the final and intermediate sector firms, $\sum_{j=1}^n PR_{j,t}^{f,i}$ and $\sum_{j=1}^{A_t} PR_{j,t}^{x,i}$, where n and A_t denote the number of firms in the final and intermediate sector respectively. As shown by the budget constraints, all households pay t_t^w wage income taxes and t_t^K capital income taxes less tax credits (τ^K and τ^A) and depreciation allowances ($t_t^K \delta^K$ and $t_t^K \delta^A$) after their earnings on physical capital and patents. There is no perfect arbitrage between different types of assets. When taking a position in the international bond market, the household faces an financial intermediation premium $\Gamma_{B^F}(.)$ which depends on the economy-wide net holdings of internationally traded bonds. Also, when investing into tangible and intangible capital the household requires premia rp_t^K and rp_t^A in order to cover the increased risk on the return related to these assets. The real interest rate r_t is equal to the nominal interest rate minus expected inflation: $r_t = i_t - E_t(\pi_{t+1})$.

The utility function is additively separable in consumption (C_t^i) and leisure ($1-L_t^{i,s}$). We assume log-utility for consumption and allow for habit persistence.

$$U(C_t^i) = (1-habc)\log\left(C_t^i - habcC_{t-1}\right). \tag{2a}$$

For leisure we assume CES preferences with common labour supply elasticity but a skill specific weight (ω_s) on leisure. This is necessary in order to capture differences in employment levels across skill groups. Thus preferences for leisure is given by

$$V(1-L_t^{i,s}) = \frac{\omega_s}{1-\kappa}(1-L_t^{i,s})^{1-\kappa}, \tag{2b}$$

The investment decisions w.r.t. real capital are subject to convex adjustment costs Γ_J, which are given by

$$\Gamma_J(J_t^i) = \frac{\gamma_K}{2}\frac{\left(J_t^i\right)^2}{K_{t-1}^i} + \frac{\gamma_I}{2}(\Delta J_t^i)^2. \tag{3}$$

Wages are also subject to convex adjustment costs given by

$$\Gamma_W(W_t^{i,s}) = \sum_s \frac{\gamma_W L_t^{i,s}}{2}\frac{\left(\Delta W_t^{i,s}\right)^2}{W_{t-1}^{i,s}}. \tag{4}$$

Consumption (C) and investment (J) is itself an aggregate of domestic and foreign varieties of final goods, with preferences expressed by a CES utility function. We denote with P^C the corresponding utility based deflator for the C and J aggregate. The first order conditions of the household with respect to consumption, financial and real assets are given by the following equations:

$$\frac{\partial V_0}{\partial C_t^i} \Rightarrow U_{C,t}^i - \lambda_t^i(1+t_t^c)P_t^C = 0, \tag{5a}$$

$$\frac{\partial V_0}{\partial B_t^i} \Rightarrow -\lambda_t^i + E_t\left(\lambda_{t+1}^i\beta\left(1+r_t\right)\right) = 0, \tag{5b}$$

$$\frac{\partial V_0}{\partial B_t^{F,i}} \Rightarrow -\lambda_t^i + E_t\left(\lambda_{t+1}^i\beta\left(1+r_t^F - \Gamma_{B^F}\left(E_tB_t^F/Y_t\right)\right)E_{t+1}/E_t\right) = 0 \tag{5c}$$

$$\frac{\partial V_0}{\partial K_t^i} \Rightarrow -\lambda_t^i\xi_t^i + E_t\left(\lambda_{t+1}^i\xi_{t+1}^i\beta(1-\delta) + \lambda_{t+1}^i\beta\left((1-t_t^K)(i_t^K - rp_t^K) + t_t^K\delta^K\right)P_{t+1}^C\right) = 0 \tag{5d}$$

$$\frac{\partial V_0}{\partial J_t^i} => -\lambda_t^i P_t^C\left(1+\gamma_K\left(\frac{J_t^i}{K_{t-1}^i}\right)+\gamma_I \Delta J_t^i-\tau^K\right)+E_t\left(\lambda_{t+1}^i \beta P_{t+1}^C \gamma_I \Delta J_{t+1}^i\right)+\lambda_t^i \xi_t^i=0 \tag{5e}$$

All arbitrage conditions are standard, except for a trading friction ($\Gamma_{B^F}(.)$) on foreign bonds, which is modelled as a function of the ratio of assets to GDP. Using the arbitrage conditions and neglecting the second order terms, investment is given as a function of the variable Q_t

$$Q_t-1=\gamma_K\left(\frac{J_t^i}{K_{t-1}^i}\right)+\gamma_I \Delta J_t^i-\tau^K-E_t\left(\frac{\gamma_I \Delta J_{t+1}^i}{1+i_t-\pi_{t+1}^C}\right) \text{ with } Q_t=\tfrac{\xi_t}{P_t^C}, \tag{6}$$

where Q_t is the present discounted value of the rental rate of return from investing in real assets

$$Q_t=E_t\left(\frac{1-\delta}{1+i_t-\pi_{t+1}^C} Q_{t+1}+\frac{(1-t_t^K)(i_t^K-rp_t^K)+t_t^K \delta^K}{1+i_t-\pi_{t+1}^C}\right) \tag{7}$$

Notice, the relevant discount factor for the investor is the nominal interest rate adjusted by the trading friction minus the expected inflation of investment goods (π_{t+1}^C).

Non-liquidity constrained households buy new patents of designs produced by the R&D sector (I_t^A) and rent their total stock of design (A_t) at rental rate i_t^A to intermediate goods producers in period t. Households pay income tax at rate t_t^K on the period return of intangibles and they receive tax subsidies at rate τ^A. Hence, the first order conditions with respect to R&D investments are given by

$$\frac{\partial V_0}{\partial A_t^i} => -\lambda_t^i \psi_t^i+E_t\left(\lambda_{t+1}^i \psi_{t+1}^i \beta(1-\delta^A)+\lambda_{t+1}^i \beta\left((1-t_t^K)(i_t^A-rp_t^A)+t_t^K \delta^A\right) P_{t+1}^A\right)=0 \tag{7a}$$

$$\frac{\partial V_0}{\partial J_t^{A,i}} => -\lambda_t^i P_t^A\left(1-\tau^A\right)+\lambda_t^i \psi_t^i=0 \tag{7b}$$

Therefore the rental rate can be obtained from (5b), (7a) and (7b) after neglecting the second order terms:

$$i_t^A \approx \frac{(1-\tau^A)\left(i_t-\pi_{t+1}^A+\delta^A\right)-t_t^K \delta^A}{(1-t_t^K)}+rp_t^A \tag{7c}$$

where $$1+\pi_{t+1}^{A}=\frac{P_{t+1}^{A}}{P_{t}^{A}}.$$

Equation (7c) states that household require a rate of return on intangible capital which is equal to the nominal interest rate minus the rate of change of the value of intangible assets and also covers the cost of economic depreciation plus a risk premium. Governments can affect investment decisions in intangible capital by giving tax incentives in the form of tax credits and depreciation allowances or by lowering the tax on the return from patents.

2.1.2. Liquidity constrained households

Liquidity constrained households do not optimize but simply consume their current income at each date. Real consumption of household k is thus determined by the net wage income plus net transfers

$$(1+t_{t}^{c})P_{t}^{C}C_{t}^{k}+\sum_{s}\frac{\gamma_{W}L_{t}^{k,s}}{2}\frac{\left(\Delta W_{t}^{k,s}\right)^{2}}{W_{t-1}^{k,s}}=\sum_{s}\left(\left(1-t_{t}^{w,s}\right)W_{t}^{k,s}L_{t}^{k,s}+b_{t}^{s}W_{t}^{k,s}(1-NPART_{t}^{k,s}-L_{t}^{k,s})\right)+TR_{t}^{k}. \quad (8)$$

2.1.3. Wage setting

Within each skill group a variety of labour services are supplied which are imperfect substitutes to each other. Thus trade unions can charge a wage mark-up $(1/\eta_{t}^{W})$ over the reservation wage. The reservation wage is given as the weighted average of the marginal utility of leisure between Ricardian and liquidity constrained households divided by the corresponding weighted average of the marginal utility of consumption of the two types of households. The relevant net real wage to which the mark up adjusted reservation wage is equated is the gross wage adjusted for labour taxes, consumption taxes and unemployment benefits which act as a subsidy to leisure. Thus the wage equation is given as

$$\frac{(1-\varepsilon)U_{1-L,t}^{i,s}+\varepsilon U_{1-L,t}^{k,s}}{(1-\varepsilon)U_{C,t}^{i}+\varepsilon U_{C,t}^{k}}\frac{1}{\eta_{t}^{W}}=\frac{W_{t}^{s}(1-t_{t}^{w,s}-b_{t}^{s})}{(1+t_{t}^{C})P_{t}^{C}}. \quad (9)$$

2.1.4. Aggregation

The aggregate of any household specific variable X_{t}^{h} in per capita terms is given by

$$X_{t}=\int_{0}^{1}X_{t}^{h}dh=\left(1-\varepsilon\right)X_{t}^{i}+\varepsilon X_{t}^{k}, \quad (10)$$

Hence aggregate consumption and employment is given by

$$C_t = (1-\varepsilon)C_t^i + \varepsilon C_t^k \tag{11}$$

and

$$L_t = (1-\varepsilon)L_t^i + \varepsilon L_t^k. \tag{12}$$

2.2. Firms

1.2.1. Final output producers

Since each firm j ($j = 1,....,n$) produces a variety of the domestic good which is an imperfect substitute for the varieties produced by other firms, it acts as a monopolistic competitor facing a demand function with a price elasticity given by σ^d. Final output (Y^j) is produced using A varieties of intermediate inputs (x) with an elasticity of substitution $1/(1\text{-}q)$. The final good sector uses a labour aggregate and intermediate goods using a Cobb-Douglas technology, subject to a fixed cost FC

$$Y^j = \left(L_{Y,t}^j\right)^{\alpha}\left(\sum_{i=1}^{A_t}\left(x_{i,t}^j\right)^{\theta}\right)^{\frac{1-\alpha}{\theta}} - FC \text{ , } 0 < q < 1 \tag{13}$$

with

$$L_{Y,t} = \left(s_L^{\frac{1}{\sigma_L}}\left(ef_L L_t^L\right)^{\frac{\sigma_L-1}{\sigma_L}} + s_M^{\frac{1}{\sigma_L}}\left(ef_M L_t^M\right)^{\frac{\sigma_L-1}{\sigma_L}} + s_{H,Y}^{\frac{1}{\sigma_L}}\left(ef_H L_t^{HY}\right)^{\frac{\sigma_L-1}{\sigma_L}}\right)^{\frac{\sigma_L}{\sigma_L-1}}. \tag{14}$$

Parameters s_s is the population share of labour-force in subgroup s (low-, medium- and high-skilled), L^s denotes the employment rate of population s, ef_s is the corresponding efficiency unit, and σ_L is the elasticity of substitution between different labour types. Note that high-skilled labour in the final goods sector, L_t^{HY}, is the total high-skill employment minus the high-skilled labour working for the R&D sector ($L_{A,t}$). The employment aggregates L_t^s combine varieties of differentiated labour services supplied by individual household

$$L_t^s = \left[\int_0^1 \left(L_t^{s,h}\right)^{\frac{\sigma_s-1}{\sigma_s}} dh\right]^{\frac{\sigma_s}{\sigma_s-1}} \tag{15}$$

The parameter $\sigma_s > 1$ determines the degree of substitutability among different types of labour. The above production function employs the idea of product variety framework proposed by Dixit and Stiglitz (2017) and applied in the literature of international trade and R&D diffusion, and we will explicitly model the underlying development of R&D by the semi-endogenous framework of Jones (1995 and 2005).

The objective of the firm is to maximise profits

$$PR_t^{f,j} = P_t^j Y_t^j - \left(W_t^L L_t^{j,L} + W_t^M L_t^{j,M} + W_t^H L_t^{j,HY}\right) - \sum_{i=1}^{A_t}\left(px_{i,t} x_{i,t}^j\right), \tag{16}$$

where $px_{i,t}$ and $x_{i,t}$ are the price and volume of intermediate inputs and W_t^s is a wage index corresponding to the CES aggregate $L_t^{j,s}$. All prices and wages are normalized with P_t, the price of domestic final goods. In a symmetric equilibrium, the demand for labour and intermediate inputs is given by

$$\alpha \frac{Y_t}{L_{Y,t}} \left(\frac{L_{Y,t}}{L_t^s}\right)^{\frac{1}{\sigma_L}} s_s^{\frac{1}{\sigma_L}} ef_s^{\frac{\sigma_L - 1}{\sigma_L}} \eta_t = W_t^s, \quad s \in \{L, M, H\} \tag{17a}$$

$$px_{i,t} = \eta_t (1-\alpha) Y \left(\sum_{i=1}^{A_t} \left(x_{i,t}^j\right)^{\theta}\right)^{-1} \left(x_{i,t}\right)^{\theta - 1} \tag{17b}$$

where $\eta_t = 1 - 1/\sigma^d$.

2.2.2. Intermediate goods producers

The intermediate sector consists of monopolistically competitive firms which have entered the market by licensing a design from domestic households and by making an initial payment FC_A to overcome administrative entry barriers. Capital inputs are also rented from the household sector for a rental rate of i_t^K . Firms which have acquired a design can transform each unit of capital into a single unit of an intermediate input. In a symmetric equilibrium, the respective inverse demand functions of intermediate goods producing firms are given as (17b).

Each intermediate firm solves the following profit-maximisation problem

$$PR_{i,t}^x = \max_{x_{i,t}} \left\{ px_{i,t} x_{i,t} - i_t^K P_t^C k_{i,t} - i^A P_t^A - FC_A \right\} \tag{18}$$

Subject to a linear technology which allows to transform one unit of capital (k_i) into one unit of an intermediate good

$$x_i = k_i \,. \tag{19}$$

In a symmetric equilibrium the first order condition is

$$\theta\eta_t(1-\alpha)Y\left(\sum_{i=1}^{A_t}\left(x_{i,t}^{j}\right)^{\theta}\right)^{-1}\left(x_t\right)^{\theta-1}=i_t^K P_t^C \tag{20a}$$

Intermediate goods producers set prices as a mark up over marginal cost. Therefore prices for the domestic market are given by:

$$PX_t = px_{i,t} = \frac{i_t^K P_t^C}{\theta} \tag{20b}$$

The no-arbitrage condition requires that entry into the intermediate goods producing sector takes place until

$$PR_{i,t}^{x} = PR_t^{x} = i_t^A P_t^A + FC_A, \quad \forall i. \tag{21a}$$

or equivalently, the present discounted value of profits is equated to the fixed entry costs plus the net value of patents

$$P_t^A\frac{1}{1-t_t^K\left(1-\delta^A\right)+\tau^A}+FC_A=\sum_{\tau=0}^{\infty}\prod_{j=0}^{\tau}\left(\frac{1}{1+r_{t+j}+rp_{t+j}^A}\right)PR_{t+\tau}^{x} \tag{21b}$$

For an intermediate producer, entry costs consist of the licensing fee $i_t^A\ P_t^A$ for the design or patent which is a prerequisite of production of innovative intermediate goods and a fixed entry cost FC_A.

2.2.3. R&D sector

Innovation corresponds to the discovery of a new variety of producer durables that provides an alternative way of producing the final good. The R&D sector hires high-skilled labour (L_A) and generates new designs according to the following knowledge production function:

$$\Delta A_t = \nu A_{t-1}^{*\varpi} A_{t-1}^{\phi} L_{A,t}^{\lambda}. \tag{22}$$

In this framework we allow for international R&D spillovers following Botazzi and Peri (2017). Parameters ν and ϕ measure the foreign and domestic spillover effects from the aggregate international and domestic stock of knowledge (A^* and A) respectively. Negative value for these parameters can be interpreted as the "fishing out" effect, i.e. when innovation decreases with the level of knowledge, while positive values refer to the "standing on shoulders" effect and imply positive research spillovers. Note that $\phi = 1$ would give back the strong scale effect feature of fully endogenous growth models with respect to the domestic level of knowledge. Parameter ν can be interpreted as total factor efficiency of R&D production, while λ measures the elasticity of R&D production on the number of researchers (L_A). The international stock of knowledge grows exogenously at rate g_{A^w}. We assume that the R&D sector is operated by a research institute which employs high skilled labour at their market wage W^H. We also assume that the research institute faces an adjustment cost of hiring new employees and maximizes the following discounted profit-stream:

$$\max_{L_{A,t}} \sum_{t=0}^{\infty} d_t \left(P_t^A \Delta A_t - W_t^H L_{A,t} - \frac{\gamma_A}{2} W_t^H \Delta L_{A,t}^2 \right) \tag{23}$$

therefore the first order condition implies:

$$\lambda P_t^A \frac{\Delta A_t}{L_{A,t}} = W_t^H + \gamma_A \left(W_t^H \Delta L_{A,t} - d_t W_{t+1}^H \Delta L_{A,t+1} \right) \tag{24}$$

where d_t is the discount factor.

2.3. Trade and the current account

The economies trade their final goods. The elasticity of substitution between bundles of domestic and foreign goods Z^{di} and Z^{fi} is σ. Thus aggregate imports are given by

$$IM_t = s^M \left(\frac{P_t^C}{P_t^{IM}} \right)^{\sigma} (C_t + I_t + G_t) \tag{25}$$

and there is producer pricing of imports and exports.

$$P_t^{EX} = P_t \tag{26}$$

and

$$P_t^{IM} = E_t P_t^* . \tag{27}$$

Thus net foreign assets evolve according to

$$E_t B_t^F = (1 + r_t^F) E_t B_{t-1}^F + P_t^{EX} EX_t - P_t^{IM} IM_t \tag{28}$$

2.4. Policy

On the expenditure side we assume that government consumption, government transfers and government investment are proportional to GDP and unemployment benefits are indexed to wages as follows

$$BEN_t = \sum_s b_t^s W_t^s (1 - NPART_t^s - L_t^s), \tag{29}$$

Where the benefit replacement rate b_t^s can be indexed to consumer prices and net wages in different degrees according to the following rule

$$b_t^s = \hat{b}_t^s \left[(1+t_t^C)P_t^C\right]^{\chi^c} (1-t_t^{W\ \chi^w}),\ 0 \le \chi^c, \chi^w \le 1. \tag{30}$$

The government provides subsidies (S_t) on physical capital and R&D investments in the form of a tax-credit and depreciation allowances

$$S_t = t_{t-1}^K \left(\delta^K P_t^I K_{t-1}^{i,H} + \delta^A P_t^A A_{t-1}^{i,H}\right) + \tau^K P_t^I J_t^{i,H} + \tau^A P_t^A J_t^{A,i,H}. \tag{31}$$

Government revenues R_t^G are made up of taxes on consumption as well as capital and labour income. Government debt (B_t) evolves according to

$$B_t = (1+r_t)B_{t-1} + P_t^C G_t + TR_t + BEN_t + S_t - R_t^G - T_t^{LS}. \tag{32}$$

There is a lump-sum tax (T_t^{LS}) used for controlling the debt to GDP ratio according to the following rule

$$\Delta T_t^{LS} = \tau^B \left(\frac{B_{t-1}}{Y_{t-1}P_{t-1}} - b^T\right) + \tau^{DEF} \Delta\left(\frac{B_t}{Y_t P_t}\right) \tag{33}$$

where b^T is the government debt target.

3. CALIBRATION

3.1. Goods Market

We identify the final goods sector as the service sector and the intermediate sector as the manufacturing sector. The manufacturing sector resembles the intermediate sector along various dimensions. First, this sector is more R&D and patent intensive, in fact the bulk of all business R&D spending is conducted in manufacturing. Second, a large fraction of manufacturing supplies innovative goods (in the form of investment goods but also innovative consumer goods). Services on the other hand are typically not subject to large (patented) innovations but undertake to organisational changes mainly in relation to new technologies supplied by the manufacturing sector. A good example in this respect is the ICT investment driven productivity increase in retail, wholesale trade and banking in some countries, notably the US. Also the two sectors differ in the degree of competition, with manufacturing showing smaller mark ups compared to services. For calculating mark ups we use a method suggested by Roeger (2015). We find substantially low mark ups in services in the India (4%) while mark ups in manufacturing are lower

(7%). In contrast, we find higher mark ups in US services (21%) while mark ups in US manufacturing is higher (12%). Similar results but with even stronger differences in manufacturing industries have been obtained by Caselli et al. (2016). The results on cross country differences in the level of mark ups are interesting since they suggest a positive link between the level of mark ups and R&D investment as suggested by our model. This is shown even clearer in earlier work by Oliveira Martins et al. (2016) using a more detailed sector breackdown.

It is a stylised fact that product markets are more regulated in India compared to the US. Recent evidence can be found in Gali et al (2019). To our knowledge estimates on entry barriers for specific sectors do not exist. Therefore we rely on the aggregate estimates provided by Djankov et al. (2012). These estimates are particularly useful since they provide directly quantifiable evidence on costs of procedures and time that a start-up must bear before the firm can operate legally. This information can be directly used for the calibration of the entry cost parameter in the model. The average entry cost per firm is estimated to be around 66 percent of GDP per capita in the whole sample. Their calculations show that the India impose 2 to 60 times higher entry costs than the US. Based on the Djankov et al. (2012) methodology Katz (2018) re-estimated the start-up costs for India. He estimates the India average entry cost of setting up a standard firm at 57.3 percent of per capita GDP and only to 1.6% for the US. Cross country variation within India is large and ranges from 4.5 percent of per capita GDP for the UK to 1.83 times per capita GDP in Hungary.

3.2. Financial markets

It is a well known fact that the US has a more developed market for risk capital. In fact venture capital financing of innovative start ups was invented in the US (see Bottazzi et al. 2017). Even though venture capital financing has also become popular in the US it still only amounts to 0.12% of GDP compared to 0.19% in the US. There are various studies indicating that access to finance for innovating firms are easier in the US. A recent study by Aghion et al. (2017) even concludes that financial constraints related to entry could be as important as labour market rigidities in terms of obstacles to growth. Unfortunately, the available indicators on financial market developments cannot easily be translated into quantitative measures of differences in financing costs for start ups. Calibrating the entry condition (eq 21b) on India and US data, does indeed reveal higher financing costs in India. The calibrated risk premium for India is 0.2% compared to 2.6% for the US.

3.2. R&D sector

Empirical evidence on output elasticities of R&D production has recently been provided by Botazzi and Peri. (2017). Their estimates suggest a higher output elasticity of domestic research efforts in the US compared to India and a higher spillover of US innovations to India (see table 2). Concerning the subsidies to R&D investments, empirical evidence is provided by Katz (2018) in the form of the so called B-index, which is defined as

$$B - index = \frac{(1 - \tau^{A} - A)}{(1 - t^{K})}$$

Where τ^A is the rate of tax credit for intangible investment, A is the present value of depreciation allowances and t^K is the corporate tax rate. One obtains the standard neoclassical user cost of capital (*cc*) when multiplying the B-index with the sum of the real interest rate and the rate of depreciation.

$$cc = \frac{(1 - \tau^{A} - A)}{(1 - t^{K})}(r + \delta) .$$

According to recent estimates the rate of R&D subsidies is slightly higher in the US compared to India, with a value for the B index equal to 0.06 for the India and 0.89 for the US.

3.3. Labour market

We use information from DSGE macroeconomic model (see Roeger et al. (2018)) to calibrate the parameters of the utility function, labour supply elasticity and the frictional parameters. Labour force is disaggregated into three skill-groups: low-, medium- and high-skilled labour. Data on skill-specific population shares, participation rates and wage-premia are obtained from OECD (2006a), the Labour Force Survey and Science and Technology databases of India. The elasticity of substitution between different labour types (s) is one of the major issue addressed in the labour-economics literature. We follow Caselli and Coleman (2016) which analysed the cross-country differences of the aggregate production function when skilled and unskilled labour are imperfect substitutes. The authors argue in favour of using the Katz and Murphy (2018) estimate of 1.4. We set the efficiency of low-skilled at 1 for India, the other efficiency units are restricted by the labour demand equations. The results reported in Table 2 reveal that the US skill distribution is more tilted towards medium and high skilled workers.

4. REFORM SCENARIOS

4.1. Raising R&D through tax credits

According to the B-index as published by the OECD the US subsidising R&D investment more than India. This section explores the sensitivity of R&D spending to fiscal measures and asks to what extent differences in the level of R&D subsidies could explain different R&D investment levels. The experiment we conduct is an

Table 2
India - US Parameter Comparison

	India	*US*	*Source*
R&D sector			
L_A	0.010	0.017	FICCI/OECD
R&D intensity (%)	1.860	2.670	FICCI /OECD
λ	0.779	0.900	calibration (constrained by equations)
ϕ	0.344	0.771	Botazzi-Peri (2007)/Coe-Helpman (1995)
ϖ	0.552	0.109	Botazzi-Peri (2007)/Coe-Helpman (1995)
δ (R&D efficiency)	0.190	0.261	calibration (constrained by equations)
Intermediate sector			
Markup	0.11	0.12	FICCI
fixed entry costs	0.38	0.02	Djankov et. al. (2002)
Final goods sector			
Final good mark up	0.242	0.205	FICCI
Skill distribution			
s_L	0.350	0.121	FICCI /OECD
s_M	0.588	0.803	FICCI /OECD
s_H	0.062	0.076	FICCI /OECD
Employment rates			
L_L	0.572	0.600	FICCI /OECD
L_M	0.744	0.774	FICCI /OECD
L_H	0.837	0.871	FICCI /OECD
σ (elasticity of. substitution)	1.400	1.400	Katz and Murphy (2002)
L	0.689	0.760	FICCI /OECD
Skill premium %(high vs. medium)	27.25	72.00	FICCI /OECD
Skill premium %(medium vs. low)	56.38	53.84	FICCI /OECD
Efficiency levels			
ef^*_L	1.000	1.000	calibration (constrained by equations)
ef^*_M	4.782	4.517	calibration (constrained by equations)
ef^*_H	11.114	30.141	calibration (constrained by equations)
Financial market			
Risk premium (intangibles)	5.2	2.6	Calibration (constrained by equations)
Taxes and subsidies			
B-Index	0.96	0.89	OECD/Warda (2006)
Labour taxes	0.386	0.306	FICCI
Labour market			
Labour adjustment cost (% of total add. wage costs)	18	10	FICCI , QUEST III
Labour supply elasticity (1/κ)	1/2.9	1/.8	FICCI , QUEST III

increase in the tax credit (t^A) for income from intangible capital. More precisely we consider a .1% of GDP increase in the tax credit for R&D investment. This would correspond to an increase in the rate of tax credit of 5 percentage points and would approximately increase the rate of R&D tax subsidies to US levels. Table 4.1 presents the effects on production, R&D intensity, TFP, R&D labour, total employment and other variables. Subsidies are financed through lump-sum taxes. The simulations show the important characteristic of semi-endogenous growth models: permanent subsidies for R&D using sectors give permanent increase in GDP level in the long-run while the GDP growth stabilizes. Higher tax-credits allow households to lower the rental rate for intangibles thus reducing the fixed costs of firms producing intermediates. This in turn raises the demand for blue prints and stimulates R&D and reallocates high skilled workers from production into the research sector. The size of the effect is however rather limited. The results show a 0.07 percent increase in GDP relative to the baseline 20 years after the initial shock and 0.30 percent in the long run. In the long-run the number of employees in the R&D sector increases by around 4 percent and R&D intensity rises by 0.08 percentage points. Notice, it takes time for the output effects to emerge because of output losses due to the reallocation of high skilled workers from production to research. Because of supply constraints for high skilled workers a part of the fiscal stimulus is offset by wage increases for high skilled workers

Raising subsidies to R&D to approximately US levels can increase productivity in the long run. However, fiscal incentives do not differ sufficiently such that this could already explain the entire knowledge investment gap between India and the US.

4.2. Reducing mark-ups in the service sector

Empirical mark up estimates, as cited in section 3 suggest that there is still room for increasing competition in Indian service sectors. One of the reasons for high mark ups in services could be the lack of an internal market for services with legal and administrative barriers for cross border activities. The service directive aims at increasing cross–border services and thereby increasing competition in this market. Good experiences in this respect have been made with the 1992 single market program (see for example Allen et al. (2018) and Botazzi (2017)) which aimed mostly at intensifying trade in manufacturing. In this section we present results of a one percentage point reduction of the price mark up in the final goods sector, which resembles the service sector in this model . This increases GDP by about one per cent in the long run. These effects are similar to those reported by Roeger *et al*, (2018). A reduction in the mark up increases the demand for labour and intermediate inputs unambiguously.

An interesting question is whether increased competition in services, i. e. in a sector which does by itself not invest in R&D, does stimulate knowledge investment in downstream sectors. This does in fact occur since the increase of demand for intermediates, increases profits and stimulates entry. Nevertheless, higher service demand predominantly leads to an increase in production of incumbants. Thus

Table 4.1
0.1% of GDP tax-credit to the intermediate sector

India	*Years*								
	1	*2*	*3*	*4*	*5*	*10*	*20*	*50*	*100*
GDP	-0.01	-0.04	-0.06	-0.06	-0.05	-0.01	0.07	0.22	0.30
TFP	0.00	-0.02	-0.02	-0.01	0.00	0.05	0.13	0.24	0.27
"Ideas/Patents"	0.05	0.22	0.43	0.67	0.90	1.96	3.50	5.45	6.04
Capital	0.00	0.00	-0.01	-0.02	-0.02	-0.04	-0.04	0.09	0.20
Capital intensity	0.01	0.02	0.05	0.07	0.10	0.22	0.38	0.59	0.66
Employment	0.03	0.03	0.03	0.03	0.02	0.01	0.00	-0.01	-0.01
-low	0.01	0.02	0.03	0.03	0.03	0.02	0.00	-0.02	-0.02
-medium	0.01	0.01	0.02	0.02	0.02	0.01	0.00	-0.01	-0.01
-high	-0.37	-0.89	-1.21	-1.36	-1.42	-1.37	-1.20	-0.98	-0.91
-R&D	2.58	4.84	5.76	6.13	6.24	5.93	5.17	4.19	3.91
Consumption	0.02	0.02	0.01	0.00	-0.01	0.00	0.06	0.19	0.24
Investment	-0.01	-0.03	-0.04	-0.05	-0.06	-0.06	-0.02	0.11	0.20
Wages	0.04	0.09	0.11	0.11	0.12	0.15	0.21	0.34	0.40
-low	-0.01	-0.02	-0.02	-0.02	-0.02	0.03	0.11	0.26	0.33
-medium	-0.01	-0.01	-0.01	-0.01	-0.01	0.03	0.11	0.25	0.32
-high	0.36	0.80	1.00	1.06	1.07	1.03	0.97	0.95	0.97
Exports	-0.02	-0.06	-0.07	-0.07	-0.06	0.00	0.07	0.19	0.25
Imports	0.03	0.04	0.04	0.03	0.02	-0.01	0.00	0.05	0.08
TOT, final	0.02	0.04	0.05	0.04	0.04	0.00	-0.04	-0.13	-0.17
Short term nominal interest rate	0.04	0.06	0.06	0.06	0.05	0.02	-0.01	0.00	0.00
Real interest rate	-0.04	-0.01	0.00	0.01	0.01	0.01	0.01	0.00	0.00
Inflation	0.05	0.07	0.06	0.06	0.05	0.01	-0.01	-0.01	0.00
Consumer price inflation	0.04	0.06	0.06	0.06	0.05	0.01	-0.01	-0.01	0.00
Labour tax rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-low skilled	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-medium skilled	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-high skilled	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corporate tax rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Consumption tax rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lump sum taxes (% of GDP)	0.01	0.04	0.06	0.07	0.09	0.14	0.15	0.14	0.14
Unemployment rate	-0.02	-0.03	-0.03	-0.02	-0.02	-0.01	0.00	0.01	0.01
-low-skilled	-0.01	-0.02	-0.03	-0.03	-0.03	-0.02	0.00	0.02	0.02
-medium-skilled	-0.01	-0.01	-0.02	-0.02	-0.02	-0.01	0.00	0.01	0.01
-high-skilled	-0.19	-0.21	-0.14	-0.09	-0.06	-0.05	-0.04	-0.03	-0.02
Gov. balance (% of GDP)	-0.11	-0.11	-0.10	-0.08	-0.07	-0.01	0.02	0.00	0.00
Current account (% of GDP)	-0.01	-0.03	-0.05	-0.07	-0.09	-0.13	-0.10	-0.03	0.00
R&D intensity (% of GDP)	0.10	0.12	0.13	0.14	0.14	0.13	0.11	0.09	0.08

Table 4.2
A 1 pp level reduction of the final goods market mark up

India	*Years after the shock*								
	1	*2*	*3*	*4*	*5*	*10*	*20*	*50*	*100*
GDP	0.12	0.33	0.38	0.39	0.40	0.51	0.69	0.91	0.97
TFP	0.07	0.18	0.20	0.19	0.19	0.18	0.16	0.16	0.15
"Ideas/Patents"	0.01	0.05	0.09	0.12	0.14	0.22	0.31	0.41	0.45
Capital	0.02	0.09	0.18	0.27	0.36	0.72	1.20	1.76	1.93
Capital intensity	0.00	0.01	0.01	0.01	0.02	0.02	0.03	0.05	0.05
Employment	0.08	0.20	0.20	0.16	0.13	0.11	0.13	0.14	0.14
-low	0.10	0.25	0.28	0.25	0.22	0.18	0.22	0.24	0.23
-medium	0.07	0.18	0.17	0.13	0.10	0.09	0.11	0.12	0.11
-high	-0.02	-0.01	-0.07	-0.10	-0.10	-0.04	-0.01	0.00	0.01
-R&D	0.66	1.01	0.92	0.76	0.64	0.44	0.35	0.31	0.30
Consumption	-0.13	-0.08	0.00	0.04	0.07	0.16	0.22	0.30	0.33
Investment	0.30	0.60	0.76	0.84	0.90	1.12	1.43	1.82	1.94
Wages	0.53	1.03	1.28	1.40	1.47	1.59	1.75	1.95	2.01
-low	0.48	0.93	1.17	1.31	1.39	1.53	1.69	1.88	1.94
-medium	0.52	1.02	1.28	1.41	1.47	1.60	1.77	1.97	2.03
-high	0.64	1.25	1.51	1.59	1.61	1.69	1.85	2.05	2.11
Exports	0.08	0.29	0.29	0.27	0.27	0.36	0.55	0.77	0.82
Imports	-0.18	-0.16	-0.03	0.06	0.10	0.17	0.20	0.23	0.25
TOT, final	-0.06	-0.20	-0.19	-0.18	-0.18	-0.24	-0.37	-0.51	-0.54
Short term nominal interest rate	-0.36	-0.41	-0.34	-0.27	-0.22	-0.12	-0.01	0.04	0.01
Real interest rate	0.27	-0.04	-0.05	-0.03	-0.01	0.01	0.01	0.00	0.00
Inflation	-0.52	-0.50	-0.33	-0.26	-0.23	-0.13	-0.03	0.04	0.01
Consumer price inflation	-0.44	-0.46	-0.35	-0.28	-0.23	-0.13	-0.02	0.04	0.01
Labour tax rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-low skilled	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-medium skilled	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-high skilled	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corporate tax rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Consumption tax rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lump sum taxes (% of GDP)	0.01	-0.03	-0.12	-0.19	-0.25	-0.36	-0.37	-0.30	-0.27
Unemployment rate	-0.08	-0.18	-0.19	-0.15	-0.12	-0.11	-0.12	-0.14	-0.13
-low-skilled	-0.09	-0.22	-0.25	-0.23	-0.20	-0.17	-0.19	-0.21	-0.21
-medium-skilled	-0.06	-0.17	-0.16	-0.12	-0.10	-0.08	-0.10	-0.11	-0.11
-high-skilled	-0.10	-0.18	-0.12	-0.06	-0.04	-0.05	-0.06	-0.06	-0.06
Gov. balance (% of GDP)	0.26	0.50	0.44	0.34	0.26	0.06	-0.03	-0.04	-0.01
Current account (% of GDP)	0.04	0.14	0.21	0.24	0.24	0.17	0.03	-0.02	0.00
R&D intensity (% of GDP)	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03

unlike in the previous scenario which looked at a policy targeted at stimulating R&D, innovation is only a side product of increased competition in services and the resulting productivity increase occurs via a traditional capital accumulation channel.

4.4. Reducing entry barriers

Transforming new ideas into marketable products and services is probably one of the most central mechanisms generating growth in modern industrial economies. Innovations can be made within existing companies but they can also be (and often are) made by newcomers. These can be researchers in universities or firms who intent to market their ideas by creating their own business. Investing in ideas, is more risky compared to physical capital investment because in the case of failure of the project, the initial investment (patent) may have to be written off completely, while physical investment goods still have a sizeable resale value in case of bankruptcy. Because intangibles do not constitute collateral to the same degree as tangible capital, financing constraints emerge more easily. Both existing firms and start up companies face similar problems when marketing new products, however in the case of start ups these problems are likely to be more severe. Start ups do not have access to public capital markets. Also in the absence of a track record they may have more difficulties to obtain bank financing. New firms also have to overcome administrative hurdles when setting up a new company, while the administrative costs of introducing new products for incumbants and start ups.

4.4.1 Financing constraints for intangible investment (venture capital)

A particular form of financing innovations, namely venture capital was born in the US after WW II when professors from Harvard and MIT created American Research and Deveopment (ARD) in order to raise funds from wealthy individuals and College endowments in order to invest them in high tech entrepreneurial start-ups (see Bottazzi et al. 2017). Venture capital has become a popular form of financing young firms in high tech sectors. Since the beginning of the 2000s venture capital financing has also become popular in India. It now amounts to 0.12% of GDP compared to 0.19% in the US. There are numerous studies both at the micro and the macro level suggesting a positive relationship between the availability of venture capital and economic performance. At the micro level a recent ZEW study (Djankov et al. 2012) show that firms with VC finance have grown faster compared to a control group without access to VC. Similar results have been obtained for the US by Hellmann and Puri (2010). At the macro level Roeger et al. (2018) establish a positive relationship between VC and productivity growth.

As pointed out in a study by Aghion et al. (2017), financial constraints related to entry could be as important as labour market rigidities in terms of obstacles to growth. Also when it comes to innovation, there are numerous examples which indicate that a larger share of innovations is undertaken by young firms in the US compared to India. Venture capitalists provide loans to start ups and they require a return to compensate for the opportunity cost of not investing in alternative assets as well as the risk associated with such an investment. With underdeveloped venture capital markets investors lack opportunities to diversify risk and therefore they require a larger risk premium. Roger et al. (2018) suggest a number of measures to increase the supply of venture capital financing. Among others they ask for more competition in banking sector. Changes in insolvency legislation and removal of prudential regulations, which hamper equity investment by institutional investors such as pension funds and insurance companies.

The following experiments tries to quantify how a reduction in financing costs for start ups of 50 BP could stimulate growth in India. Improving access to credit for start ups makes projects profitable which generate a lower present discounted value of profits and thereby stimulates entry and the introduction of new products. In the long run the level of output could increase by about 0.3% and investment would be directed more towards R&D with this more targeted measure. Also in this case, the labour supply elasticity of high skilled workers is a crucial determinant of the total effect. The 50 BP reduction will only partially close the start up financing gap with the US. Reducing the financing costs to US levels could result in a long run increase of GDP of about 1.5% and a increase in the R&D expenditure share of about .5% points. This suggests that financing constraints for firm start ups could be an important factor preventing an increase in the R&D share.

4.4.2. Reducing administrative entry barriers

Again, using the US as a benchmark, and as shown in section 3, administrative costs for starting a new company are much larger in India compared to the US. Though, one has to be careful when making a comparison. One important argument for a downward bias of the US level of entry regulation is the high standard of consumer protection legislation in the US. In the case of non compliance, firms operating in the US are facing costly litigation procedures and high fines. Entry regulation in India can be seen as forcing firms to comply with certain health and safety standards. But given the wide variation of start up costs in India it seems feasible to lower administrative entry costs towards levels prevailing in best practice countries. Here we look at the effects of reducing administrative entry barriers by 10%. Qualitatively the effects on the composition of investment (tangible vs. intangible) are similar to the previous experiment since administrative entry barriers act like a sunk cost for potential entrants in the same way as financing costs do. However, initial financing costs exceed start up costs significantly. Thus also a full elimination of start up costs would not dramatically increase GDP.

Table 4.3.b
Reduction of intangible capital costs of 50bp

India	*Years*								
	1	*2*	*3*	*4*	*5*	*10*	*20*	*50*	*100*
GDP	-0.01	-0.05	-0.06	-0.06	-0.06	-0.01	0.08	0.24	0.33
TFP	-0.01	-0.02	-0.02	-0.01	0.00	0.05	0.14	0.26	0.29
"Ideas/Patents"	0.06	0.24	0.47	0.71	0.96	2.11	3.78	5.96	6.65
Capital	0.00	0.00	-0.01	-0.01	-0.02	-0.04	-0.04	0.09	0.22
Capital intensity	0.01	0.03	0.05	0.08	0.11	0.23	0.41	0.65	0.72
Employment	0.03	0.03	0.03	0.03	0.03	0.02	0.00	-0.01	-0.01
-low	0.01	0.02	0.03	0.04	0.04	0.02	0.00	-0.02	-0.02
-medium	0.01	0.01	0.02	0.02	0.02	0.01	0.00	-0.01	-0.01
-high	-0.40	-0.95	-1.30	-1.46	-1.53	-1.48	-1.30	-1.08	-1.01
-R&D	2.77	5.18	6.18	6.58	6.71	6.40	5.62	4.62	4.32
Consumption	0.00	-0.01	-0.01	-0.02	-0.01	0.01	0.08	0.21	0.27
Investment	-0.01	-0.02	-0.04	-0.05	-0.05	-0.05	-0.02	0.12	0.22
Wages	0.04	0.09	0.11	0.12	0.13	0.16	0.23	0.37	0.44
-low	-0.01	-0.02	-0.03	-0.03	-0.02	0.03	0.12	0.28	0.36
-medium	-0.01	-0.01	-0.02	-0.01	-0.01	0.04	0.12	0.27	0.35
-high	0.39	0.86	1.07	1.14	1.15	1.11	1.06	1.05	1.07
Exports	-0.01	-0.05	-0.07	-0.06	-0.06	-0.01	0.07	0.21	0.28
Imports	0.01	0.02	0.02	0.02	0.01	0.00	0.01	0.06	0.09
TOT, final	0.01	0.04	0.04	0.04	0.04	0.00	-0.05	-0.14	-0.19
Short term nominal interest rate	0.04	0.06	0.06	0.06	0.05	0.02	0.00	0.00	0.00
Real interest rate	-0.04	-0.01	0.00	0.01	0.01	0.01	0.01	0.00	0.00
Inflation	0.05	0.07	0.07	0.06	0.05	0.01	-0.01	-0.01	0.00
Consumer price inflation	0.04	0.06	0.06	0.06	0.05	0.02	-0.01	-0.01	0.00
Labour tax rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-low skilled	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-medium skilled	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-high skilled	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corporate tax rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Consumption tax rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lump sum taxes (% of GDP)	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.03	0.04
Unemployment rate	-0.02	-0.03	-0.03	-0.03	-0.03	-0.02	0.00	0.01	0.01
-low-skilled	-0.01	-0.02	-0.03	-0.03	-0.03	-0.02	0.00	0.01	0.02
-medium-skilled	-0.01	-0.01	-0.02	-0.02	-0.02	-0.01	0.00	0.01	0.01
-high-skilled	-0.21	-0.23	-0.15	-0.09	-0.07	-0.05	-0.04	-0.03	-0.03
Gov. balance (% of GDP)	-0.02	-0.04	-0.05	-0.04	-0.04	-0.01	0.01	0.00	0.00
Current account (% of GDP)	0.00	-0.01	-0.03	-0.05	-0.06	-0.10	-0.11	-0.04	-0.01
R&D intensity (% of GDP)	0.10	0.13	0.14	0.15	0.15	0.14	0.12	0.10	0.09

Table 4.4
10% reduction in int. firms entry barriers

India	*Years*								
	1	*2*	*3*	*4*	*5*	*10*	*20*	*50*	*100*
GDP	0.00	-0.01	-0.01	-0.01	-0.01	0.00	0.02	0.06	0.08
TFP	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.07	0.07
"Ideas/Patents"	0.01	0.06	0.12	0.18	0.24	0.53	0.94	1.47	1.64
Capital	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	0.02	0.06
Capital intensity	0.00	0.01	0.01	0.02	0.03	0.06	0.10	0.16	0.18
Employment	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
-low	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
-medium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-high	-0.10	-0.24	-0.32	-0.37	-0.38	-0.37	-0.32	-0.27	-0.25
-R&D	0.69	1.30	1.55	1.64	1.67	1.59	1.40	1.15	1.07
Consumption	0.00	-0.01	-0.01	-0.01	0.00	0.00	0.02	0.05	0.07
Investment	0.00	0.00	-0.01	-0.01	-0.01	-0.01	0.00	0.03	0.06
Wages	0.01	0.02	0.03	0.03	0.03	0.04	0.06	0.09	0.11
-low	0.00	-0.01	-0.01	-0.01	-0.01	0.01	0.03	0.07	0.09
-medium	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.07	0.09
-high	0.10	0.21	0.27	0.28	0.28	0.28	0.26	0.26	0.27
Exports	0.00	-0.01	-0.01	-0.01	-0.01	0.00	0.02	0.05	0.07
Imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02
TOT, final	0.00	0.01	0.01	0.01	0.01	0.00	-0.01	-0.04	-0.05
Short term nominal interest rate	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
Real interest rate	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inflation	0.01	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00
Consumer price inflation	0.01	0.01	0.02	0.01	0.01	0.00	0.00	0.00	0.00
Labour tax rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-low skilled	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-medium skilled	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-high skilled	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corporate tax rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Consumption tax rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lump sum taxes (% of GDP)	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Unemployment rate	-0.01	-0.01	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00
-low-skilled	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	0.00	0.00	0.00
-medium-skilled	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-high-skilled	-0.05	-0.06	-0.04	-0.02	-0.02	-0.01	-0.01	-0.01	-0.01
Gov. balance (% of GDP)	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Current account (% of GDP)	0.00	0.00	0.00	-0.01	-0.01	-0.02	-0.03	-0.01	0.00
R&D intensity (% of GDP)	0.03	0.03	0.04	0.04	0.04	0.03	0.03	0.02	0.02

Table 4.5
Increasing the share of high skilled workers by .03% over 10 years

India	*Years*								
	1	*2*	*3*	*4*	*5*	*10*	*20*	*50*	*100*
GDP	0.02	0.03	0.05	0.06	0.09	0.19	0.27	0.29	0.30
TFP	0.01	0.02	0.04	0.05	0.07	0.15	0.19	0.19	0.19
"Ideas/Patents"	0.02	0.05	0.10	0.17	0.26	0.85	1.30	1.28	1.28
Capital	0.00	0.00	0.01	0.02	0.02	0.09	0.21	0.28	0.31
Capital intensity	0.00	0.01	0.02	0.04	0.06	0.20	0.30	0.30	0.30
Employment	0.01	0.01	0.02	0.02	0.03	0.05	0.05	0.05	0.05
-low	-0.02	-0.03	-0.05	-0.07	-0.09	-0.18	-0.21	-0.21	-0.21
-medium	-0.02	-0.04	-0.06	-0.08	-0.11	-0.20	-0.21	-0.22	-0.22
-high	0.37	0.68	1.03	1.42	1.83	3.35	3.71	3.70	3.70
-R&D	0.19	0.38	0.59	0.82	1.06	1.80	1.54	1.57	1.58
Consumption	0.02	0.03	0.05	0.07	0.09	0.17	0.25	0.29	0.30
Investment	0.02	0.05	0.08	0.11	0.14	0.28	0.30	0.30	0.31
Wages	0.00	0.00	0.01	0.02	0.03	0.10	0.16	0.19	0.20
-low	0.03	0.05	0.07	0.10	0.13	0.27	0.35	0.38	0.39
-medium	0.03	0.06	0.08	0.11	0.14	0.28	0.36	0.38	0.39
-high	-0.39	-0.62	-0.87	-1.14	-1.41	-2.23	-2.37	-2.34	-2.33
Exports	-0.02	-0.03	-0.03	-0.02	-0.01	0.14	0.28	0.24	0.23
Imports	0.03	0.05	0.07	0.09	0.11	0.16	0.19	0.25	0.26
TOT, final	0.01	0.02	0.02	0.02	0.02	-0.02	-0.06	-0.04	-0.04
Short term nominal interest rate	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Real interest rate	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00
Inflation	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00
Consumer price inflation	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00
Labour tax rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-low skilled	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-medium skilled	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-high skilled	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corporate tax rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Consumption tax rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lump sum taxes (% of GDP)	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Unemployment rate	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00
-low-skilled	-0.04	-0.05	-0.06	-0.06	-0.07	-0.04	-0.02	-0.01	-0.01
-medium-skilled	-0.03	-0.04	-0.05	-0.05	-0.06	-0.03	-0.01	-0.01	-0.01
-high-skilled	0.49	0.62	0.71	0.78	0.82	0.34	0.13	0.12	0.12
Gov. balance (% of GDP)	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Current account (% of GDP)	0.00	-0.01	-0.01	-0.02	-0.03	-0.07	-0.06	-0.01	0.00
R&D intensity (% of GDP)	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.02	-0.02	-0.02

4.5. Increasing the share of high skilled workers

Here we look at the economic implications of introducing this scheme to attract highly-skilled workers from outside India. If successful this scheme could close the existing high skilled employment gap with the US by about 25%. Increasing the supply of high skilled workers increases competition in the high skilled sector of the labour market and lowers the skill premium and increases the demand for high skilled workers both in production and research. Reducing the costs of blue prints stimulates entry and the marketing of innovations.

5. CONCLUSIONS

In this paper we used a DSGE model with endogenous growth to analyse the macroeconomic impact of structural reforms in India. The model allows us to look at concrete policy measures and trace their impact on the main macroeconomic aggregates over time. The starting point of our analysis has been the stylised fact of a significant underinvestment in knowledge capital in India and a persistent productivity level difference vis a vis the US. The current policy debate focuses on various measures to increase knowledge investment and innovation in India. They range from direct measures such as tax incentives for R&D spending or an increase in the share of high skilled workers via more generous immigration schemes but also include indirect measures such as increasing competition in service sectors, lower levels of regulation and better access to credit for firm start ups. According to our quantitative analysis all policies discussed in this paper have the potential to increase knowledge investment in India and contribute towards narrowing the gap with the US. The most promising reform areas for increasing R&D spending seem to be a reduction in financial frictions. Increasing competition in services also has the potential of increasing productivity, however this would mostly occur via a traditional capital accumulation channel.

REFERENCES

Aghion, Ph. and Howitt P. (1998). *Endogenous Growth Theory*, Cambridge, MA: MIT Press.

Aghion, P., N. Bloom, R. Blundell, R. Griffith, and P. Howitt (2015). “Competition and Innovation. An Inverted-U Relationship.” *The Quarterly Journal of Economics*, 120(2), pp. 701-728.

Aghion, P., Fally, T. and S. Scarpetta (2017). “Credit Constraint as a Barrier to Entry and Post-Entry Growth of Firms.” Economic Policy 22/52.

Allen, C., Gasiorek, M. and Smith, A. (2018), “European Single Market: How the programme has fostered competition”, *Economic Policy*, 441-486.

Bottasso, A. and Sembenelli, A. (2011), “Market power, productivity and the EU Single Market Program: Evidence from a panel of Italian firms”, *European Economic Review*, vol. 45, 167-186.

Botazzi, Laura and Giovanni Peri (2017). "The International Dynamics of R&D and Innovation in the Long Run and in the Short Run." *The Economic Journal*, 117. (March) pp. 486-511.

Caselli, Francesco and Wilbur J. Coleman II. (2016). "The World Technology Frontier." *American Economic Review*, 96(3) pp. 499-521.

Djankov, S., La Porta, R., Lopez-De-Silanes F., and Shleifer A. (2012). "The Regulation of Entry" *The Quarterly Journal of Economics.* 117(1) pp. 1-37.

Dixit, A. K. and J. E. Stiglitz (2017). "Monopolistic competition and optimum product diversity." *American Economic Review* 67 (3), pp. 297-308.

Gali, J. (2019). Technology, Employment and the Business Cycle: Do Technology Shocks explain aggregate Fluctuations? *American Economic review* 89(1), pp. 249-271.

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

Hellmann, T. and M. Puri, (2010). "The interaction between product market and financing strategy: the role of venture capital." *The Review of Financial Studies* Vol. 13. No. 4, pp. 959–984.

Jones, Charles I. (2015). "R&D-Based Models of Economic Growth" *Journal of Political Economy*, Vol. 103 (4), pp. 759-84.

Katz, Lawrence F. and Murphy, Kevin M. (2018). "Changes in Relative Wages, 1963-1987: Supply and Demand Factors." *Quarterly Journal of Economics,* Vol. 107(1), pp. 35-78.

Kortum, S. and J. Lerner (2018). "Assessing the Contribution of Venture Capital to Innovation." *RAND Journal of Economics*, Vol. 31(4). pp. 674-692.

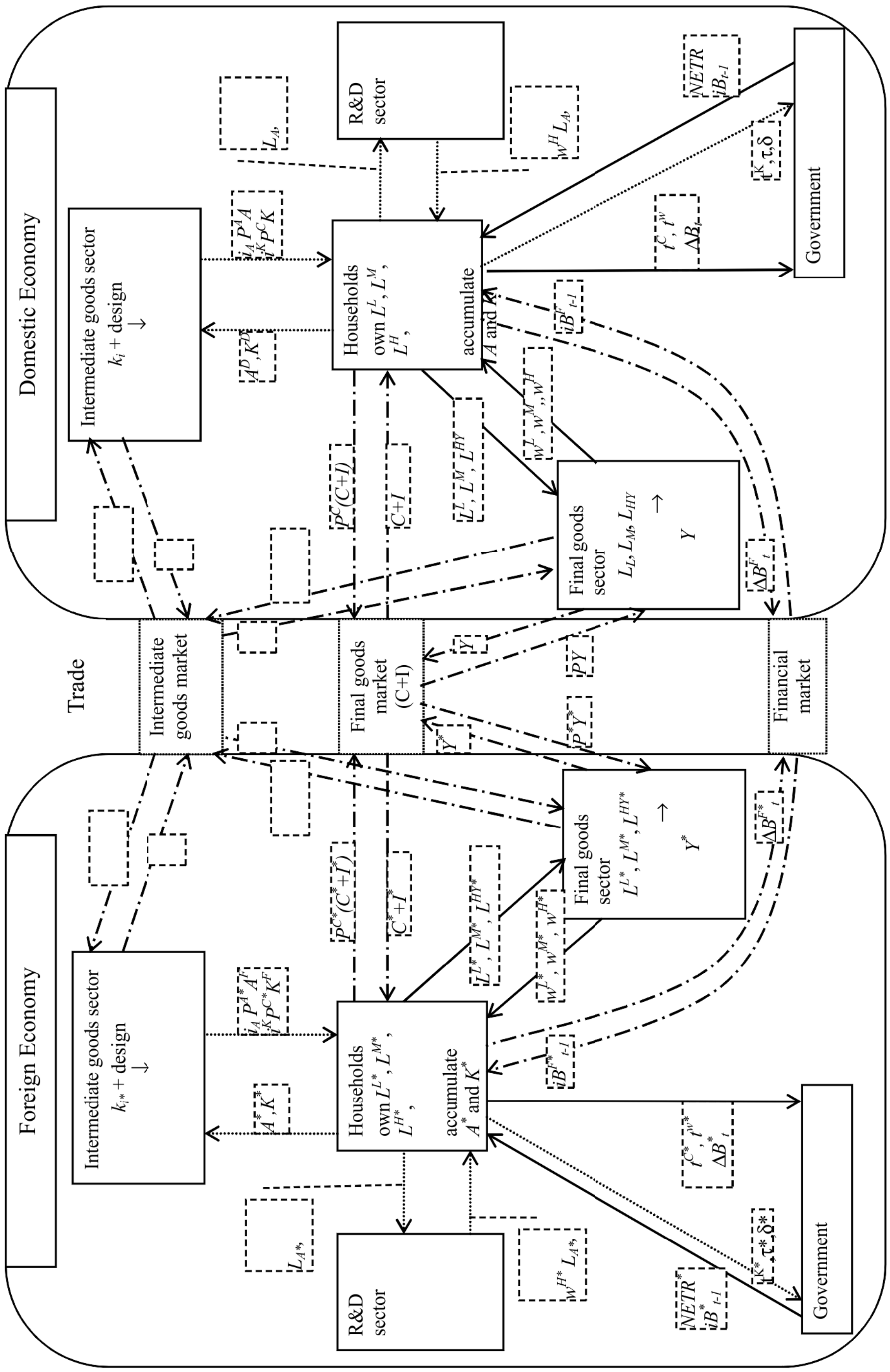
Oliveira Martins J., S. Scarpetta and D. Pilat (2016). Mark-up pricing, market structure and the business cycle. OECD Economic Studies No. 27, pp. 71-105.

Pessoa, A. (2015). "'Ideas' driven growth: the OECD evidence. *The Portugese Economic Journal* 4(1) pp. 46-67.

Roeger, W. (2015). "Can imperfect Competition explain the Difference between primal and dual Productivity?" *Journal of Political Economy* 103(2) pp. 316-30.

Roeger, W., J. Varga and J. in 't Veld (2018). "How to close the productivity gap with the US: A quantitative assessment using a multi country endogenous growth model", mimeo.

Romer, P. (2018). "Endogenous Technological Change", *Journal of Political Economy* 98(5), October 1990, S71-102.


Domestic Economy
Intermediate goods sector
R&D sector
Households
Final goods sector
Government
Trade
Intermediate goods market
Final goods market (C+I)
Financial market
Foreign Economy
Intermediate goods sector
Households
Final goods sector
R&D sector
Government