Monopoly Rights Can Reduce Income Big Time[*]

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Abstract

We ask for which part of the observed cross–country differences in the level of per–capita income monopoly rights can account. We answer this question in a calibrated growth model with capital. Monopoly rights in the capital–producing sector shield labor market insiders from the competition by outsiders and permit coalitions of these insiders to choose inefficient technologies or working practices. We find that monopoly rights can reduce the level of per–capita income by quantitatively substantial amounts that are much larger than previously claimed. Moreover, the effects of monopoly rights on the price of capital goods relative to consumption goods and the investment share in output are quantitatively consistent with the Penn World Tables. The key to our findings is that monopoly rights in the capital–producing sector do not only reduce total factor productivity there but also increase the relative price of capital. This reduces the capital–labor ratio in the rest of the economy.

Keywords: cross–country income differences; cross–country productivity differences; monopoly rights; relative price of capital; capital accumulation.
JEL classification: EO0; EO4.

1 Introduction

There are large cross–country differences in the levels of per–capita income. For example, the Penn World Table of 1996 (PWT96 henceforth) report that the average per–capita income of the richest ten percentile of countries is about thirty times that of the poorest ten percentile.[1] We ask for which part of this income difference monopoly rights in the labor market can account. We define monopoly rights as follows: certain types of workers, which we call insiders, have a monopoly in supplying labor in certain sectors; moreover, coalitions of these insiders have the right to block the use of efficient technologies and best–practice working arrangements.

Real–world examples of insider coalitions are brotherhoods, guilds, professional associations, and trade unions. Many studies document the various blocking activities of insider coalitions; examples include Clark (1987), Mokyr (1990), Wolcott (1994), McKinsey-Global-Institute (1999), Holmes and Schmitz (2001a,b), Parente and Prescott (2000), and Schmitz (2001b). The paper by Wolcott (1994) provides an instructive example. She compares the Japanese and the Indian Textile Industries between 1920 and 1938. In 1920, both industries had comparably low levels of output per worker. However, over the next 18 years, output per worker in Japan increased threefold whereas it remained stagnant in India. Moreover, Total Factor Productivity (TFP henceforth) in Japan increased by 61 percent in spinning and by 77 percent in weaving whereas these measures in India increased by only 1 and 21 percent. Finally, in the Japanese textile industry the real wage increased by 3 percent more than in agriculture, whereas in the Indian textile industry it increased by 13 percent more than in agriculture. Wolcott documents that the main difference between Japan and India lay in the working arrangements. Most importantly, in Japan rationalization increased the number of machines each worker operated whereas in India this did not happen. Wolcott argues that differences in the characteristics of the workforce are responsible for the different experiences. In particular, the workers in

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[1]Parente and Prescott (1993) and McGratten and Schmitz (1999) offer a detailed analysis of cross-country data.

Japan were predominately young women, who worked in the textile industry only for some years. There were no labor unions in Japan. In contrast, the workers in India were predominately adult males, who worked in the textile industry for most of their lives. There were strong labor unions in India. As a result the Bombay region alone witnessed about 1000 strikes in the inter–war period, most of which were aimed at preventing measures of rationalization that would have improved labor productivity and reduced employment.

We study the quantitative implications of monopoly rights in the labor market of an exogenous growth model with capital. In contrast, the existing literature abstracts from capital when studying the qualitative and quantitative implications of monopoly rights; see for example Holmes and Schmitz (1995), Parente and Prescott (1999), and Herrendorf and Teixeira (2002). Analyzing the implications of monopoly rights in a growth model with capital is important for three reasons. First, we will be able to use the development facts about the cross–country differences in the relative price of capital to calibrate the cross–country differences in monopoly rights. Second, it will turn out that the presence of capital greatly amplifies the distortionary effects of monopoly rights. This confirms a conjecture of Parente and Prescott (1999) and shows that capital is essential for understanding the quantitative implications of monopoly rights. Third, our theory of development will also be a theory of growth because our model will be consistent with both several key development facts and with Kaldor's growth facts. This is desirable because development and growth theory are two closely related fields.

We consider a model economy with two final–goods sectors, which we call the service sector and the manufacturing sector, and many intermediate good sectors. The service sector produces a consumption good and the manufacturing sector produces a consumption good and a capital good. The inputs in the production of the service good are capital and labor; the inputs in the production of the manufactured goods are the intermediate goods, and the inputs in the intermediate goods are capital and labor. The economy is populated by many individuals, who can work in the service sector and in the intermediate good sectors and who can save by investing in physical capital. There are different types:

an individual can be either an insider in one intermediate good sector or an outsider. The only difference between insiders and outsiders comes from the institutional arrangement, which may grant the insiders the monopoly of supplying labor in their intermediate good sector. If they have the monopoly, then the entry of outsider labor into their intermediate good sector is restricted. If they do not, then the entry of outsider labor into their intermediate good sector is not restricted. Moreover, we assume that the insiders of each intermediate good sector form a coalition that the institutional arrangement grants these coalitions the right to choose the insider productivity in their sector. The outsiders do not have a monopoly right and they do not belong to a coalition.

Our main finding is that differences in the strength of monopoly rights account for a quantitatively substantial part of the cross–country differences in income levels. Our baseline calibration uses the PWT96, a capital share of 0.4, and assumes that the higher prices of capital relative to consumption in poor countries come from stronger monopoly rights. For this baseline calibration, we find an income level difference of a factor of 10.8 between the Balanced Growth Path equilibria with competition and with monopoly rights. This is four times the difference of a factor 2.7 found by Parente and Prescott (1999) for a model economy without capital. The effect of monopoly rights is larger in our model economy with capital because the standard direct effect is accompanied by a new indirect effect. The direct effect is that monopoly rights allow the insider coalitions to reduce the insider productivity. This leads to the inefficient production of the intermediate input goods for the manufactured goods. The indirect effect is that the reduced insider productivity increases the price of intermediate goods and manufactured goods relative to services. Since capital is a manufactured good, this reduces the capital–labor ratio in the service sector. Our quantitative results show that this indirect effect greatly amplifies the direct effect of monopoly rights.

Our model economy does quantitatively well also with respect to three other features of the development data. (i) It predicts that the price of capital relative to consumption should be higher in poor than in rich countries. This consistent with the evidence re-

ported by Jones (1994), Chari et al. (1996), Eaton and Kortum (2001), and Restuccia and Urrutia (2001). In our model the price of capital relative to consumption is higher in poor economies because the price of services (which are an important part of consumption) relative to domestic capital is lower. In contrast, the price of domestic capital relative to foreign capital is independent of the income level. Both of these features are consistent with the evidence reported by Hsieh and Klenow (2002). (ii) Our model predicts that measured in domestic prices, rich countries should invest the same output shares as poor countries; measured in international prices, rich countries should invest considerably larger output shares than poor countries. Furthermore, the predicted shares are quantitatively close to those in the PWT96. (iii) Our model predicts that rich countries should use their resources more efficiently than poor countries, so cross–country differences in TFP account for a substantial part of the differences in income levels. The predicted TFP differences are quantitatively well within the range reported by Caselli et al. (1996), Klenow and Rodriguez-Clare (1997), Prescott (1998), Hall and Jones (1999), and Caselli and Coleman (2003).

2 Model Economy

2.1 Environment

Time t is discrete and runs forever. There is no uncertainty. There are two consumption goods: services and manufactured consumption. We denote their period–t quantities by s_t and m_t. There is a finite measure of individuals, who can be outsiders or insiders. Specifically, there is a unit square of outsiders and a unit square of insiders. The outsiders are identical whereas the insiders can be of different types: for each $i \in [0, 1]$, there is a unit interval of identical insiders of type i. We use the subscript $\iota \in \{o, [0, 1]\}$ to indicate an individual's type.

We start with preferences. All individuals have identical preferences over sequences

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of the two consumption goods, which we represent by a time–separable utility function:

$$\sum_{t=0}^{\infty} \beta^t u(s_t, m_t), \qquad u(s_t, m_t) \equiv \frac{(s_t^\alpha m_t^{1-\alpha})^{1-\rho} - 1}{1 - \rho}. \tag{1}$$

$\beta \in (0,1)$ is the discount factor, $\alpha \in (0,1)$ is the expenditure share of services, and $\rho \in [0, \infty)$ is the inverse of the intertemporal elasticity of substitution.

We continue with endowments. In each period, all individuals of type ι are endowed with one unit of type–ι labor. In the initial period, all individuals of type ι are moreover endowed with strictly positive quantities of installed capital $k_{\iota 0}$. Installed capital depreciates at rate $\delta \in [0,1]$. Denoting by x_t the quantity of period–t investment, type ι's installed capital stock follows the following law of motion:

$$k_{\iota t+1} = (1 - \delta)k_{\iota t} + x_{\iota t}.$$

We now turn to technology. There are two final goods sectors. The service sector produces services and the manufacturing sector produces manufactured consumption and capital. There is also a continuum of intermediate good sectors. Production in all sectors takes place under constant returns. The technology of the service sector is represented by:

$$s_t \leq A k_{st}^\theta (\gamma^t l_{st})^{1-\theta}, \quad l_{st} = l_{sot} + \int_0^1 l_{sit} di, \quad s_t, k_{st}, l_{sit} \geq 0, \quad l_{sot} > 0. \tag{2}$$

k_{st} is the installed capital allocated to the service sector; l_{st}, l_{sot}, and l_{sit} are the total labor and the outsider and type–i insider labor allocated to the service sector; $A > 0$ is TFP in the service sector;[2] $\theta \in (0,1)$ is the capital share; $\gamma - 1 \in [0, \infty)$ is the exogenous growth rate of labor–augmenting technical progress. The formulation of the production function contains the restriction $l_{sot} > 0$ on outsider labor. This restriction will rule out equilibria

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[2]The common practice is to normalize units such that $A = 1$. We deviate from that practice because we want units in the model to be the same as in the data. The reason for this will become clear in Section 4.

in which the service sector uses only insider labor. Such equilibria are not interesting to us because we want some outsiders to work in the competitive service sector.

We continue with the technology of the manufacturing sector:

$$\mu m_t + x_t \leq \left(\int_0^1 z_{it}^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}}, \quad m_t, x_t, z_{it} \geq 0. \tag{3}$$

z_{it} denotes the quantity of the intermediate input i; $\mu > 0$ is a constant that determines the units of m_t; $\sigma \in (0, \infty)$ is the elasticity of substitution between different intermediate goods. As Parente and Prescott (1999), we will need that the substitutability between two different intermediate goods is sufficiently low: $\sigma < 1$. This implies that the manufacturing sector's demand for each intermediate good is inelastic. Note that one can guarantee an inelastic demand by considering sufficiently broad categories of intermediate goods.[3]

We finish with the technology of the i–th intermediate good sector. To simplify matters, we assume that it cannot use insider labor of type $j \neq i$. This is without loss of generality because we will restrict our attention to symmetric equilibrium with respect to the different types of insiders and the different sectors. The technology is represented by:

$$z_{it} \leq k_{z_i t}^{\theta} (\gamma^t l_{z_i t})^{1-\theta}, \quad l_{z_i t} = (1-\omega) l_{z_i ot} + b_{it} l_{z_i it}, \quad z_{it}, k_{z_i t}, l_{z_i ot} \geq 0, \quad l_{z_i it} > 0. \tag{4}$$

$k_{z_i t}$ is the installed capital allocated to the i–th intermediate good sector and $l_{z_i t}$, $l_{z_i ot}$, and $l_{z_i it}$ are the total labor, the outsider labor, and the insider labor allocated to the i–th intermediate good sector. The assumption $l_{z_i it} > 0$ will ensure that some insiders work in their intermediate good sector.

$b_{it} \in [1 - \omega, 1]$ is a variable that affects the productivity of the insiders in the i–th intermediate good sector and $\omega \in [0, 1)$ is a parameter that affects the productivity of the

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[3]It may be easier to understand (3) in two steps: (i) the manufacturing sector produces a new intermediate good called y_t; (ii) the manufacturing sector transforms y_t into m_t and x_t according to $\mu m_t + x_t \leq y_t$. Note that the common practice is to normalize units such that $\mu = 1$. We again deviate from that practice because we want units in the model and in the data to be the same. The reason for this will become clear in Section 4.

outsiders. The first case is that $\omega = 0$. On the one hand, if $b_{it} = 1$ in addition, then insider and outsider labor are perfect substitutes. On the other hand, if $b_{it} < 1$ in addition, then outsider labor is more productive than insider labor. In other words, if $\omega = 0$, then the insiders have no monopoly power. We refer to this case as *competition*. The second case is $\omega > 0$. On the one hand, if $b_{it} = \omega$ in addition, then insider and outsider labor are again perfect substitutes. On the other hand, if $b_{it} > 1 - \omega$ in addition, then insider and outsider labor are imperfect substitutes and insider labor is more productive. In other words, if $\omega > 0$, then the insiders have monopoly power. We refer to this second case as *monopoly*. The strength of the monopoly power increases in the value of ω. We interpret ω as summarizing the legal and institutional restrictions on outsider labor's entry into the i–th intermediate good sector.

The insiders of each type i form a coalition. The institutional arrangement is such that the i–th coalition has the right to choose b_{it}. This right prevails both under competition and under monopoly, which is convenient but has no effect on the BGP equilibrium. The assumption that $b_{it} \in [1 - \omega, 1]$ implies that the most inefficient productivity is $1 - \omega$. Allowing $b_{it} \in [0, 1]$ would add irrelevant cases but not change any of our results. Moreover, there are no costs of choosing the highest productivity and there are no vintage–specific skills. Nonetheless, we will show that the coalitions choose inefficient productivities if they have monopoly power.

We finish the description of the environment with the timing of events. The coalitions choose the insider productivity in period $t - 1$ at the same time when the other decisions of period $t - 1$ are taken. Trade takes place in sequential markets. In each period there are markets for the two consumption goods, the capital good, each intermediate good, installed capital, outsider labor, and each type of insider labor. Moreover, we assume that the two manufactured goods are tradable in the world market whereas the service good and the intermediate goods are not tradable in the world market. Finally, we assume that our economy is small and open: it does not affect the world market price of the tradable

goods.[4]

2.2 Equilibrium

Our environment gives rise to a dynamic game. We restrict our attention to equilibria with the following properties: (i) they are symmetric with respect to insiders, the outsiders, the coalitions, and the intermediate goods sectors; (ii) they are recursive in that in each period all decision makers condition their actions on the state variables only.

We start with the description of the state variables. We denote the state of exogenous technological progress γ^t by Γ. Its law of motion is $\Gamma' = \gamma\Gamma$ where the initial Γ equals 1. As before, we denote the states that different individuals and the coalitions choose by lower–case letters. We also need the economy–wide averages of such states, which we denote by upper–case letters. So, b is the insider productivity parameter in an intermediate good sector and B is the economy–wide average insider productivity parameter.[5] Furthermore, the outsiders' and insiders' individual holdings of capital are k_o and k_i and their economy–wide average holdings are K_o and K_i. For compactness, we abbreviate the economy–wide state: $F \equiv (\Gamma, B, K_i, K_o)$. Its law of motion is:

$$F' = (\Gamma', B', K_i', K_o') = (\Gamma'(F), B'(F), K_i'(F), K_o'(F)) = F'(F).$$

We will finally need the sector–wide average of the insiders' capital holdings, which we indicate by a bar: $\bar{k}_i$. The law of motion of the sector–wide state is

$$(b', \bar{k}_i') = (b'(F, b, \bar{k}_i), \bar{k}_i'(F, b, \bar{k}_i)).$$

We choose the foreign capital good as the numeraire. This is convenient because our small open economy does not affect the world market price of foreign capital. The

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[4]The only role this assumption will play is to pin down the price of domestic capital relative to foreign capital at one. Thus, our model will be consistent with the evidence reported by Hsieh and Klenow (2002) that the price of domestic capital relative to foreign capital is unrelated to the per–capita income level.

[5]We can drop the sector index because of symmetry.

relative prices of the service good, the manufactured consumption good, and the domestic capital good and the rental rates of outsider labor and of installed capital are functions of the aggregate state: $p_s(F)$, $p_m(F)$, $p_x(F)$, $w_o(F)$, and $r(F)$. The relative price of the intermediate good and the rental rate of insider labor depend also on the productivity parameter b: $p_z(F, b)$ and $w_i(F, b)$.

We now turn to the problems of the different individuals. The representative outsider chooses his current consumption and future capital stock, taking as given the economy–wide state F, the corresponding law of motion $F'(.)$, and his own capital stock k_o:

$$v_o(F, k_o) = \max_{s_o, m_o, k_o' \geq 0} \{u(s_o, m_o) + \beta v_o(F', k_o')\} \tag{5a}$$

$$s.t. \ p_s(F)s_o + p_m(F)m_o + p_x(F)[k_o' - (1 - \delta)k_o] = r(F)k_o + w_o(F),$$

$$F' = F'(F),$$

where v_o denotes his value function. The solution to this problem implies the policy function $(s_o, m_o, k_o') = (s_o(F, k_o), m_o(F, k_o), k_o'(F, k_o))$. Note that we have omitted, and will omit, profits. This is without loss of generality because constant returns and price–taking behavior imply that profits are zero.

The representative insider chooses his current consumption and future capital stock, taking as given the economy–wide state F, the corresponding law of motion $F'(.)$, the insider productivity parameter b and the average insider capital of his sector $\bar{k}_i$, the corresponding law of motion $(b'(.), \bar{k}_i'(.))$, and his own capital stock k_i:

$$v_i(F, b, \bar{k}_i, k_i) = \max_{s_i, m_i, k_i' \geq 0} \{u(s_i, m_i) + \beta v_i(F', b', \bar{k}_i', k_i')\} \tag{5b}$$

$$s.t. \ p_s(F)s_i + p_m(F)m_i + p_x(F)[k_i' - (1 - \delta)k_i] = r(F)k_i + w_i(F, b),$$

$$(F, b, \bar{k}_i)' = (F'(F), b'(F, b, \bar{k}_i), \bar{k}_i'(F, b, \bar{k}_i)).$$

The solution to this problem implies the policy function $(s_i, m_i, k_i') = (s_i(F, b, \bar{k}_i, k_i), m_i(F, b, \bar{k}_i, k_i), k_i'(F, b, \bar{k}_i, k_i))$.

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The representative firms of the different sectors behave competitively, that is, they take all prices as given when they maximize their profits subject to their production functions:[6]

$$\max_{s, k_s, l_{so}, l_{si}} p_s(F)s - r(F)k_s - w_o(F)l_{so} - w_i(F, B)l_{si} \quad \text{s.t.} \quad s \leq Ak_s^\theta[\Gamma(l_{so} + l_{si})]^{1-\theta}, \quad (6a)$$

$$\max_{m, x, \{z_i\}_{i=0}^1} p_m(F)m + p_x(F)x - \int_0^1 p_z(F, B)z_i di \quad \text{s.t.} \quad (3), \quad (6b)$$

$$\max_{z, k_z, l_{zo}, l_{zi}} p_z(F, b)z - r(F)k_z - w_o l_{zo}(F) - w_i(F, b)l_{zi} \quad \text{s.t.} \quad (4). \quad (6c)$$

The solutions to these problems imply the firms' policy functions:

$$(s, k_s, l_{so}, l_{si}) = (s(F, B), k_s(F, B), l_{so}(F, B), l_{si}(F, B)),$$

$$(m, x, z_i) = (m(F, B), x(F, B), z_i(F, B)),$$

$$(z, k_z, l_{zo}, l_{zi}) = (z(F, b), k_z(F, b), l_{zo}(F, b), l_{zi}(F, b)).$$

We now turn the problem of the representative insider coalition. Note that it is small relative to the rest of the economy, so it does not affect aggregate variables. However, it is large in its sector where it can choose the future, sector–wide insider productivity. It makes that choice so as to maximize the indirect insider utility plus the continuation value, taking as given the economy–wide state F, the corresponding law of motion $F'(.)$, the sector–wide state $(b, \bar{k}_i)$, and the law of motion of the sector–wide average insider capital, $\bar{k}_i'(.)$:

$$v_c(F, b, \bar{k}_i) = \max_{b' \in [1-\omega, 1]} \{u(s_i(F, b, \bar{k}_i, \bar{k}_i), m_i(F, b, \bar{k}_i, \bar{k}_i)) + \beta v_c(F', b', \bar{k}_i')\} \quad (7)$$

$$\text{s.t.} \quad (F', \bar{k}_i') = (F'(F), \bar{k}_i'(F, b, \bar{k}_i)).$$

A solution to this problem implies the policy function $b_c' = b_c'(F, b, \bar{k}_i)$.

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[6]Note that we have dropped the time indices and set $\Gamma = \gamma^t$ in (6a) and (6c). Note too that imposing symmetry simplifies (2) to the production function in (6a). Note finally that we cannot impose symmetry on (6b) yet because we have not derived the demand for each intermediate good.

Imposing consistency across the laws of motions and the solutions to the different problems leads to the following conditions:

$$K_o'(F) = k_o'(F, K_o), \tag{8a}$$

$$K_i'(F) = \bar{k}_i'(F, B, K_i) = k_i'(F, B, K_i, K_i), \tag{8b}$$

$$B'(F) = b_c'(F, B, K_i) = b'(F, B, K_i). \tag{8c}$$

Finally, the market clearing conditions are:

$$s(F, B) = s_o(F, K_o) + s_i(F, B, K_i, K_i), \tag{9a}$$

$$m(F, B) = m_o(F, K_o) + m_i(F, B, K_i, K_i), \tag{9b}$$

$$z(F, B) = z_i(F, B), \tag{9c}$$

$$x(F, B) = [k_o'(F, K_o) + k_i'(F, B, K_i, K_i)] - (1 - \delta)(K_o + K_i), \tag{9d}$$

$$K_o + K_i = k_s(F, B) + k_z(F, B), \tag{9e}$$

$$1 = l_{so}(F, B) + l_{zo}(F, B), \tag{9f}$$

$$1 = l_{si}(F, B) + l_{zi}(F, B). \tag{9g}$$

The left–hand sides list the supplies and the right–hand sides list the demands of the different goods. In particular, the first two conditions require that the markets for the two consumption goods clear. The third market–clearing condition requires that the market for a typical intermediate good clears. The fourth and the fifth market–clearing conditions require that the markets for new and installed capital clear, and the last two market–clearing conditions require that the markets for the different types of labor clear.

Note that we have abstracted from borrowing and lending between insiders and outsiders and between the domestic economy and the rest of world. This is without loss of generality because we will only compare different balanced growth path (BGP henceforth) equilibria. Without borrowing and lending between domestic and foreign individuals, in-

ternational trade is balanced in each period. Consequently, international trade will just pin down the relative prices of tradable goods at $p_m = \mu$ and $p_x = 1$. It is therefore without loss of generality that we have restricted imports and exports to be zero when writing the market clearing conditions.

Definition 1 (Equilibrium) *Let $p_m = \mu$ and $p_x = 1$. An equilibrium is*

– price functions $(p_s, w_o, r)(.)$, $(p_z, w_i)(.)$;

– laws of motion $F'(.)$, $b'(.)$, $\bar{k}'_i(.)$;

– value functions $v_o(.)$, $v_i(.)$, $v_c(.)$;

– policy functions for the individuals, $(s_o, m_o, k'_o)(.)$ and $(s_i, m_i, k'_i)(.)$, for the firms, $(s, k_s, l_{so}, l_{si})(.)$, $(m, x, z_i)(.)$, $(z, k_z, l_{zo}, l_{zi})(.)$, and for the coalition, $b'_c(.)$;

such that:

– the value functions satisfy (5a), (5b), and (7);

– the policy functions solve problems (5a), (5b), (6a)–(6c), and (7);

– the policy functions are consistent with the laws of motion, i.e. (8a)–(8c) holds;

– markets clear, i.e. (9a)–(9g) holds.

3   Analytical Results

We now study the BGP equilibria of the model economy with competition and with monopoly. Recall that these two cases correspond to $\omega = 0$ and $\omega > 0$ and that an increase in ω corresponds to an increase in the strength of the monopoly. Recall too that we have assumed that the coalition maintains the right to choose its members' productivity also if $\omega = 0$.

To ensure that the individual optimization problems are well defined, we need the standard restriction that the growth rate of labor–augmenting technological progress is not too large relative to the discount factor: $\beta\gamma^{1-\rho} \in (0, 1)$. We are now in the position to state the first analytical result. Its proof, and those of all the following propositions, is in the appendix.

Proposition 1 (BGP equilibrium with competition, $\omega = 0$) *There exists a unique BGP equilibrium. Along the BGP equilibrium*

(a) the capital stocks and all sectors' outputs grow at rate $\gamma - 1$;

(b) productivity in the intermediate good sectors is constant and $b = 1$;

(c) the relative price of services is constant and $p_s = A^{-1}$;

(d) the outsiders and the insiders are indifferent between the service sector and the intermediate good sectors.[7]

A BGP equilibrium with monopoly exists only if the parameters satisfy the following two additional conditions:

Assumption 1

$$\alpha\beta\theta(\gamma + \delta - 1)(2 - \omega) < [\alpha - (1 - \alpha)(1 - \omega)][\gamma^\rho + \beta(\delta - 1)], \tag{10a}$$

$$2\alpha\beta\theta(\gamma + \delta - 1) > (2\alpha - 1)[\gamma^\rho + \beta(\delta - 1)]. \tag{10b}$$

Conditions (10) ensure that the coalition's optimal choice of b clears the goods market; see the appendix for the formal details. Standard calibrations like that of Section 4 below satisfy these conditions.

Proposition 2 (BGP equilibrium with monopoly, $\omega > 0$) *Let Assumption 1 hold. There exists a unique BGP equilibrium. Along the BGP equilibrium*

(a) the capital stocks and all sectors' outputs grow at rate $\gamma - 1$;

(b) productivity in the intermediate good sectors is constant and $b \in (1 - \omega, 1)$;

(c) the relative price of services is constant and $p_s = (1 - \omega)^{1-\theta} A^{-1}$;

(d) the outsiders work only in the service sector but are indifferent between the service sector and the intermediate good sectors, the insiders work in their intermediate good sector and strictly prefer that.

Why does the representative coalition find it optimal to choose a lower productivity than is possible when it has monopoly power? To answer this question, consider for a

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[7]Strictly speaking the BGP equilibrium is not unique because outsider and insider labor are perfect substitutes so the allocation of labor is indeterminate. However, all of these equilibria are equivalent, as they have the exact same quantities of physical goods and the exact same utilities.

moment what a monopolist producer in an intermediate sector would do instead of an insider coalition. He would choose a higher relative price of the intermediate good than the competitive one so as to restrict production. In our environment with inelastic demand, the optimal choice would be the highest relative price at which entry does not occur. Thus, a monopolist producer would make other firms just indifferent between entering and staying out. Now turn back to the insider coalition in an intermediate sector. The insider coalition cannot directly choose a higher relative price of the intermediate good because that relative price is determined by competition among the firms. However, the insider coalition can indirectly choose a higher relative price of the intermediate good by choosing an inefficient insider productivity. Given that the demand for intermediate goods is inelastic, choosing an inefficient productivity increases the real insider income because it increases the relative price by more than it decreases the insiders' marginal product. The insiders' monopoly power is limited by the entry of outsiders into the intermediate goods sector. If entry occurs in equilibrium, then the relative price must be such that the outsiders earn the same wage in the service sector as in the intermediate good sector. In this case, choosing a lower insider productivity only decreases the marginal insider product, and so the real insider income. Thus, the insider coalition's optimal productivity choice results in a relative price that makes the outsiders just indifferent between the service sector and the intermediate good sector.

The implications of our model are consistent with the standard growth facts and with the development facts described in the introduction. To generate the growth implications, we need to keep the strength of the monopoly power constant. It then easy to show that for any $\omega \in [0, 1)$ the unique BGP equilibrium is consistent with Kaldor's growth facts: per–capita income and per–capita capital grow at a constant rate $\gamma - 1$; the capital–output ratio, the real interest rate, and the capital and labor shares in output are all constant. To generate the development implications of our model, we need to vary the strength of monopoly power. We also need to define TFP. In the intermediate good sector $TFP_z \equiv (\Gamma b)^{1-\theta}$. On the aggregate, we define TFP as the empirical literature: TFP is the

residual that would result if aggregate output was produced from aggregate capital and labor according to an aggregate Cobb–Douglas production function with capital share θ:

$$TFP \equiv \frac{p_s K_s^\theta L_s^{1-\theta} + K_z^\theta L_z^{1-\theta}}{(K_s + K_z)^\theta 2^{1-\theta}}, \tag{11}$$

Computing aggregate TFP in this way allows us to compare our results with those obtained by the empirical literature.

Proposition 3 (Development facts)   *Let Assumption 1 hold.*
(a) In any BGP equilibrium with $\omega \in [0, 1)$ the growth rates of all real variables, the price of domestic capital relative to foreign capital, and the investment share measured in domestic prices are the same.
(b) In any BGP equilibrium with monopoly, $\omega \in (0, 1)$, the values of the following variables are smaller than in the BGP equilibrium with competition, $\omega = 0$: the level of per–capita income; the price of services relative to capital goods; the investment share measured in international prices; TFP in the intermediate good sectors and aggregate TFP. Moreover, the values of these variables decrease when ω increases.

Put together, the different parts of this proposition imply that: (i) the relative price of services is positively correlated with per–capita income; (ii) measured in domestic prices the investment share in output is uncorrelated with income whereas measured in international prices it is positively correlated with income; (iii) TFP in the intermediate good sectors and aggregate TFP are positively correlated with income. These are qualitative versions of the development facts described in the introduction.

One may wonder why monopoly reduces the relative price of services, instead of increasing the relative prices of intermediate goods and manufactured goods. The reason is that in symmetric equilibrium both the prices of intermediate goods relative to the domestic capital and the price of the domestic capital relative to foreign capital must equal one. The latter holds because domestic capital is tradable in our model. An increase in the relative price of the intermediate goods relative to the domestic service good can

then only come from a decrease in the price of the domestic service good relative to the intermediate and manufacturing goods. This is possible because domestic services are not tradable.

We end this section by noting that monopoly rights reduce the capital–labor ratios of *all* sectors, not just of the intermediate good sectors. This can be seen from the Euler equations, which in a BGP equilibrium with $\omega \in (0, 1)$ become:

$$\theta \left(\frac{\Gamma b}{K_z} \right)^{1-\theta} = p_s \theta \left(\frac{\Gamma}{K_s} \right)^{1-\theta} = \frac{\gamma^\rho}{\beta} - 1 + \delta. \tag{12}$$

The direct effect of monopoly rights is to decrease b, which decreases the capital–labor ratio in the intermediate goods sectors. Notice that there is no relative price effect in the intermediate good sector because $p_z = 1$ in symmetric BGP equilibrium. The indirect effect of monopoly rights is to decrease p_s, which makes allocating capital to the service sector more expensive and decreases the capital–labor ratio in services. Therefore, capital provides an amplification mechanism by which the monopoly distortion in the intermediate good sectors affects the competitive service sector. This amplification mechanism turns out to be important for the quantitative analysis to which we turn now.[8]

4 Quantitative Results

In this section, we explore the quantitative implications of monopoly rights. We first calibrate the model economy with competition by identifying it with the ten percent richest countries in the world. We then calibrate the strength of the monopoly power, ω, by assuming that the difference in the price of services relative to capital between the richest and the poorest ten percentiles comes from monopoly rights. We finally ask by how much the per–capita income level of the competitive economy would change if we replaced competition by monopoly of strength ω.

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[8]Schmitz (2001a) makes a similar point: if the government produces investment goods inefficiently, then this reduces the labor productivity of all sectors that use these investment goods. Schmitz finds that for Egypt this effect causes about an income–level difference of a factor three.

A model period is one year. Table 1 summarizes the parameter values for the benchmark calibration.[9] Instead of calibrating all parameters to the richest ten percent of countries, we go with the standard post–war values for the U.S. if they are available. Our justification is that the U.S. is by far the biggest and most studied economy in the top ten percentile and the economy with the best data sources. As in Cooley and Prescott (1995), we therefore choose $\gamma = 1.0156$, $\rho = 1$, $\beta = 0.947$, and $\theta = 0.4$. We will explore our model economy also for other values of θ because there is some debate about its value; see Gollin (2002) for example. Note that we have restricted all sectors to have equal capital shares. Hsieh and Klenow (2002) find that this is a reasonable approximation for the US. In contrast, Echevarria (1997) finds that across the OECD, the average capital share in services is higher than in manufacturing (fifty versus forty percent). In light of her evidence, our choice of a capital share in services of forty percent is a conservative one, as monopoly rights generate larger differences in the per–capita income levels when the capital share increases.

To calibrate the remaining parameter values, we use data from the PWT96.[10] Following Hsieh and Klenow (2002), we use benchmark years because they are the only years for which price data are actually collected. Unfortunately the number and identity of the countries vary widely across the different benchmark years. We therefore do not calibrate the BGP equilibrium under competition to a panel of cross–country data but turn instead to the cross–section of the PWT96. The PWT96 is the most recent available benchmark study and it has the advantage of being very broad: it contains 115 countries. We start by identifying the countries in the top and bottom ten percentiles of per–capita incomes, measured in international prices. We find the standard fact that the average per–capita income of the top ten percentile is about 30 times larger than that of the bottom ten percentile.

We proceed by assuming that the top ten percentile in the PWT96 corresponds to our economy under competition and use weighed averages from the top ten percentile

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[9]Note that we do not need to choose a value for σ, because it drops out in symmetric equilibrium.
[10]Recall that PWT96 abbreviates the 1996 Penn World Tables.

to calibrate δ, α, A, and μ. In particular, the value of δ determines the investment share in output measured in domestic prices. In the top ten percentile of the PWT96, the weighed average share equals 0.23, where the weights are the countries per–capita incomes relative to the total per–capita income in the top ten percentile and incomes are in international prices. Given our choices of $\omega = 0$ and $\theta = 0.4$, we need to choose $\delta = 0.06$ to replicate this share. The value of α equals the expenditure share of non–tradable consumption goods in total consumption measured in domestic prices. In the top ten percentile of the PWT96, the weighed average share equals 0.58, where the weights are the countries' quantities of consumed services relative to the total quantity of consumed services in the top ten percentile and quantities are in international prices.[11] The value of A determines the price of non–tradable consumption goods relative to tradable capital goods. In the top ten percentile of the PWT96, the weighed average relative price equals 0.78, where the weights are the countries quantities relative to the total quantity in the top ten percentile and quantities are in international prices.[12] Since $p_s = A^{-1}$ along the BGP with competition, we choose $A = 1.28$. The value of μ determines the price of manufactured consumption goods relative to capital goods. Since both are assumed tradable and since we have a small open economy, the corresponding price in the data is the international price of manufactured consumption goods relative to capital goods in the whole sample. This international price equals 0.47 and so we choose $\mu = 0.47$.[13]

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[11]Note that our assumption of a constant expenditure share of services is not validated by the data: the poorest ten percentile on average spend less than half on services than the richest ten percentile. However, this goes against us because the service sector is the competitive sector in our model economy. Note too that quantities in international prices are in fact values. We nonetheless stick to quantity terminology because the Penn World Tables use it.

[12]To be precise the price in a country is the weighed average of the prices of the different categories of goods. The average price across a percentile of countries is the weighed average of the prices. In both cases, the weights are the quantities relative to the relevant total quantity measured in international prices. As capital goods we classify all capital goods including non–tradable construction. As tradable consumption goods we classify beverages, bread and cereal, cheese and eggs, clothing (including repair), fish, floor covering, fruit, fuel and power, furniture, household appliances and repairs, household goods and textiles, meat, milk, oil and fat, other food, personal transportation equipment, tobacco, and vegetables and potatoes. As non-tradable consumption goods we classify cafes and hotels, communication, education, gross rent and water charges, medical health care, operation of transportation equipment, purchase transportation service, recreation and culture, restaurants, and other goods and services.

[13]The international price is defined recursively. The international price of a category of goods equals the weighed average of the prices of that category in the different countries; the weights are the quantities relative to the total quantity and the prices in the countries are the domestic prices multiplied with the

Given the values of θ and A, the value of ω determines the price of the non–tradable consumption goods relative to the capital good in the economy with monopoly: $p_s = (1 - \omega)^{1-\theta} A^{-1}$. The ratio between of this price between the poorest and richest ten percentile equals 7.7. Using $(1 - \omega)^{\theta-1} = 7.7$ and $\theta = 0.4$, we thus set $\omega = 0.967$ in our benchmark calibration. At first sight, this value may appear to be very large. However, it is important to note that the output share not going to the outsiders, $k_{z_i}^{\theta}(\omega l_{z_i o})^{1-\theta}$, will remain strictly smaller than the labor share times the annual output of the intermediate good sector, that is, 60 percent of annual output. Parente and Prescott (1999) argue that the costs of breaking labor market monopolies can easily be of this order magnitude. A different way of checking whether $\omega = 0.967$ is reasonable is to look at the implied premium of the insider wage over the outside wage. For our benchmark calibration, it turns out to equal 30 percent. A wage premium of 30 percent is very reasonable for an economy with strong monopoly rights, given the size of the observed inter–industry wage differentials in the US for workers with the same characteristics. Holmes and Schmitz (2001a), for example, report that in New Orleans in the mid 1880s screwmen and longshoremen earned monopoly wage premia of between 18 and 31 percent of the total transportation costs of the goods they handled. Given a labor share of 60 percent, a wage premium of 30 percent translates into 18 percent of the total production costs (recall that the producers make zero profits in our model). Another piece of evidence is that there are large and persistent wage premia in the 1980s [Krueger and Summers (1988)]. For example, in 1984 the workers in U.S. automobile manufacturing received a wage premium of nearly 30 percent over the average wage of all workers with the same characteristics.

Table 1: Benchmark Calibration

γ	ρ	β	θ	δ	α	A	μ	ω
1.0156	1	0.947	0.4	0.06	0.58	1.28	0.47	0.967

purchasing–power–parity of the domestic currency; the purchasing–power–parity equals the ratio between the domestic goods basket evaluated in domestic and international prices.

Table 1 summarizes the parameter values of our benchmark calibration and Table 2 summarizes our quantitative results. The numbers in the boldfaced line of Table 2 correspond to the parameter values of Table 1. The first column indicates the capital shares that we have explored other than $\theta = 0.4$. If θ changes, we re–calibrate the values of δ and ω so as to maintain unchanged the investment share in domestic prices and the ratio of the relative prices of services. The second column reports the ratios of the per–capita incomes with competition and monopoly. In all cases, we compute per–capita income as in the PWT96, so the quantities generated by the model are evaluated at the international prices p_s^*, p_m^*, and p_x^* from the PWT96:

$$Y_\omega^* \equiv p_s^* S_\omega + p_m^* M_\omega + p_x^* X_\omega.$$

This makes sense because we have chosen the units of the final goods such that all relative prices of the model economy under competition are equal to those of the top ten percentile of the PWT96. In other words, the units in the model are equal to the units in the PWT96.

The ratio between the level of per–capita income with competition and monopoly is between a factor of 6 and 30. For our baseline calibration $\theta = 0.4$, the result is a factor of 10.8. This is four times the factor of 2.7 reported by Parente and Prescott (1999) for a model without capital accumulation. The last line of Table 2 reports that for a capital share of 0.54 our model economy generates roughly the observed income ratio of 30. While we think that values of this size are on the very high end of plausible capital shares, the result is interesting in light previous work: Mankiw et al. (1992) and Chari et al. (1996) found that without cross–country differences in TFP, an even larger capital share of 0.7 is needed to generate the observed income difference. We will return to this issue in the next section when we discuss a tax distortions as an alternative to the monopoly rights distortion.

The third and fourth columns of Table 2 report the investment shares in output with competition and monopoly, both measured in international prices. The predicted

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Table 2: Quantitative results monopoly economy (c for competition, ω for monopoly)

θ	$\frac{Y_c^*}{Y_\omega^*}$	$\frac{I_c^*}{Y_c^*}$	$\frac{I_\omega^*}{Y_\omega^*}$	$\frac{TFP_{z,c}^*}{TFP_{z,\omega}^*}$	$\frac{TFP_c^*}{TFP_\omega^*}$
0.3	6.6	0.29	0.12	6.6	2.9
0.35	8.3	0.29	0.12	6.7	2.9
0.4	**10.8**	**0.29**	**0.12**	**6.7**	**2.9**
0.45	14.6	0.30	0.12	6.8	2.9
0.54	30.2	0.29	0.12	6.9	2.9

investment shares are reasonably close to those found in the PWT96, where the richest and poorest ten percentile invests 27 and 10 percent of output measured in international prices, respectively. Note that the model also performs well with respect to the investment share measured in domestic prices. While we target the 23 percent that the richest ten percentile invest on average, Proposition 3 predicts the same percentage for the poorest ten percentile. This is consistent with the finding of Hsieh and Klenow (2002) that across countries the investment share measured in domestic prices is unrelated to the per–capita income level.

The fifth column reports the ratios between TFP in the intermediate goods sectors with competition and monopoly. The model predicts that TFP in the intermediate goods sectors with competition should be between 6.6 and 6.9 times larger than TFP with monopoly. Sector TFP differences of that order of magnitude are well within reason. For example, the estimates of Harrigan (1999) show that a difference in sector TFP of a factor 2 is common even across OECD countries. A specific example is Britain before the Thatcher reforms of the labor market took place: Harrigan estimates that in 1980 TFP in the production of machinery and equipment was about three times larger in the US than Britain. Since these estimates are just for OECD countries, one expects considerably larger differences in sector TFP between OECD countries and developing countries.[14]

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[14]Note that sector–TFP differences of a factor 6.5 do not only come from using inefficient technologies but also from inefficient work practices. There is ample evidence that inefficient work practices alone can reduce productivity significantly. For example, Clark (1987) documents that in 1910 differences in work practices generated cross–country differences of a factor 7 in the labor productivity of cotton–textile mills. Schmitz (2001b) documents that in the 1980s the US and Canadian iron-ore industries doubled their labor productivities by basically changing their work rules.

The sixth column reports the ratios between aggregate TFP with monopoly and competition, where aggregate TFP is defined in expression (11). The model predicts that aggregate TFP with competition should be 3 times larger than with monopoly. The estimates of Hall and Jones (1999) show that aggregate TFP differences of a factor of 2 to 3 are common, even though they control for human capital differences. For example, they estimate aggregate TFP differences between the US and India of a factor of 2.5 and between Italy and India of a factor of 2.9. Given that our model abstracts from human capital accumulation, differences in aggregate TFP of a factor 3 are well within reason.

Table 3: Different percentiles of countries (c for competition, ω for monopoly)

n	$\dfrac{Y_{top\,n\%}}{Y_{bot\,n\%}}$	$\dfrac{p_{s,\,top\,n\%}}{p_{s,\,bot\,n\%}}$	$\dfrac{Y_c^*}{Y_\omega^*}$	$\dfrac{\text{4. column}}{\text{2. column}}$
10	**30.4**	**7.7**	**10.8**	**0.35**
20	18.3	5.4	7.7	0.42
30	11.5	4.6	6.3	0.54
40	7.7	3.4	4.4	0.57

To establish the robustness of our results, we conduct sensitivity analysis with respect to the number of countries and the parameter values. With respect to the number of countries, we explore how the model's predictions change if we calibrate δ, α, A, and ω to the data of the richest and poorest 20, 30, and 40 percentiles of countries. In this exercise, we leave the other parameter values unchanged. The results are summarized in Table 3. The first column lists the percentiles considered, the second column lists the ratios of the per–capita income levels in the richest versus the poorest n percentiles, the third column list the ratios of the relative prices of services in the richest versus the poorest n–th percentiles, the fourth column lists the ratios of the per–capita income levels in model economy with competition versus monopoly, and the last column lists the ratio of the fourth divided by the second column. We see that the differences in income and in the relative price ratios fall as we take averages over more countries. However, the part of the income difference explained by the model (column five) rises considerably (from 35 to 57 percent). This suggests that our results are not specific to the richest and poorest

10 percentiles.

With respect to the parameter values, we explore how the model's predictions change if we change one parameter value at a time. Note that it does not make sense to change the values of A and μ because their chosen values are the only ones that make the units in the model coincide with those in the data. We find that our results are robust to changes in values of γ, ρ, β, δ, and α.[15] In contrast, Table 4 shows that our results are very sensitive to the choice of ω. This should not be interpreted as a weakness of the model though because ω measures the strength of monopoly power, and that is the key variable.

Table 4: Different monopoly power (c for competition, ω for monopoly)

ω	$\dfrac{p_{s,c}}{p_{s,\omega}}$	$\dfrac{Y_c^*}{Y_\omega^*}$	$\dfrac{I_c^*}{Y_c^*}$	$\dfrac{I_\omega^*}{Y_\omega^*}$	$\dfrac{TFP_{z,c}^*}{TFP_{z,\omega}^*}$
0.950	6.0	8.5	0.29	0.14	5.3
0.961	7.0	9.9	0.29	0.13	6.2
0.966	**7.7**	**10.8**	**0.29**	**0.12**	**6.7**
0.974	9.0	12.5	0.29	0.11	7.9
0.979	10.0	13.7	0.29	0.10	8.8

5 Discussion

In this section, we discuss several of our key modeling choices.

Why have we attributed the cross–country difference in the relative price of services to monopoly rights? An alternative would have been to attribute it to a tax τ on the purchase of intermediate goods, which would have been in the spirit of what Chari et al. (1996) and Restuccia and Urrutia (2001) do in a one–sector model. To answer this question, we now explore briefly the quantitative implications of such a tax. In this exercise, we can abstract from insiders and outsiders and assume that there is one representative individual

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[15]The results are available upon request.

with two units of time. The representative individual now solves:

$$v(F, k) = \max_{s, m, k' \geq 0} \{u(s, m) + \beta v(F', k')\} \tag{13}$$

$$s.t. \ \ p_s(F)s + p_m(F)m + p_x(F)[k' - (1 - \delta)k] = r(F)k + w(F) + T(F),$$

$$F' = F'(F).$$

$T(F)$ is the lump–sum rebate of the tax revenue on purchases of manufactured goods:

$$T(F) = \tau p_z(F)z(F).$$

The technologies in the service sector and the manufacturing sector are the same as with monopoly rights. The technologies in the intermediate good sector is the previous technology with $\omega = 0$ and $b = 1$. The difference to monopoly rights is that the manufacturing firms now pay $(1 + \tau)p_z(F)$ for intermediate input goods, instead of $p_z(F, B)$.

We solve the model with a tax in the appendix. We choose the tax rate such that the ratio of the prices of non–tradable consumption relative to capital without and with the tax equals 7.7. Given a choice of θ, we again choose δ such that the model economy without taxes has an investment share of 0.23 measured in domestic prices. The results are reported in Table 5.

Table 5: Quantitative results tax economy
(0 for no tax, τ for tax)

θ	$\frac{Y_0^*}{Y_\tau^*}$	$\frac{I_0^*}{Y_0^*}$	$\frac{I_\tau^*}{Y_\tau^*}$
0.3	3.8	0.29	0.06
0.35	4.7	0.29	0.06
0.4	**6.1**	**0.29**	**0.06**
0.45	8.3	0.30	0.06
0.59	29.4	0.29	0.06

Comparing Tables 2 and 5, we see two main differences between monopoly and taxes: (i) monopoly reduces the level of income by much more than taxes; (ii) taxes reduce the

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investment share by much more than monopoly. Comparing the investment shares, we see that with monopoly they are much closer to the 11 percent in the data than with taxes. This provides support for our assumption that monopoly rights, and not taxes, are the main driving force of the cross–country difference in relative prices. Finally, comparing the last rows of Tables 2 and 5, we see that for a tax to generate the income level difference observed in the data, we would need an even higher capital share than with monopoly rights. Interestingly, however, that capital share would still be lower than what Mankiw et al. (1992) and Chari et al. (1996) needed (0.59 instead of 0.7).[16]

Why have we chosen to represent monopoly rights as part of the technology? Parente and Prescott (1999) modeled them more explicitly in an entry game. Unfortunately, analyzing this entry game is too complicated in the neoclassical growth model with capital. We therefore propose a more abstract way of modeling monopoly rights that remains tractable when there is capital. To gain some confidence in the robustness of our specification, we have considered two alternative formulations. The first formulation has outsiders and insiders produce with different capital stocks:

$$z = k_{zo}^{\theta}[\Gamma(1-\omega)l_{zo}]^{1-\theta} + k_{zi}^{\theta}(\Gamma b l_{zi})^{1-\theta}.$$

This could be the case, for example, if the entry of outsiders happened through the entry of new firms that hired only outsiders. This formulation does not make a difference for our results, so our choice has the advantage of reducing notation. The second formulation has the coalition choose not only the insider productivity but also that of the outsiders:

$$z = k_{z}^{\theta}\{\Gamma b[(1-\omega)l_{zo} + l_{zi}]\}^{1-\theta}.$$

This would be the case if the insiders had more monopoly power than in our specification.

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[16]The intuitive reasons for the differences between monopoly rights and a tax are as follows. Monopoly reduces the productivity in manufacturing and leads to over–staffing (i.e. all insiders work in manufacturing with monopoly), whereas taxes do not have these effects. Thus, monopoly has a larger effect on income. Taxes increase the relative price of capital for both sectors whereas monopoly increases the relative price of capital only for the service sector. Thus, taxes have a larger effect on the capital stock.

With this formulation the BGP equilibrium with monopoly becomes indeterminate.[17] So our specification has the advantage of leading to a unique BGP equilibrium, which implies that comparative static exercises are well defined.

Why have we assumed that monopoly rights apply to manufacturing and not to services? The first reason is that having monopoly rights in services instead of in manufacturing would increase the relative price of services. Thus, the model would make the counterfactual prediction that poorer countries have higher relative prices of services. The second reason is that the production of manufactured goods is often more standardized and takes place on a larger scale than the production of service goods, making it easier for the workforce in manufacturing sectors to organize itself and lobby for monopoly rights. It should be mentioned that having monopoly rights in both manufacturing and services should strengthen our results. The reason is that the having monopoly rights in the service sector would reduce output there and increase the relative price of services. Thus, the monopoly rights in manufacturing would have to be even stronger than in our model in order to generate the low observed relative price of services in poor countries.

Why have we assumed that the coalitions can just choose the insider productivity, and not wages or hours worked? First, we could incorporate a wage choice as in Parente and Prescott (1999) without changing the results. Thus, abstracting from this choice is not restrictive. Second, since Cozzi and Palacios (2003) show that a choice of hours cannot be incorporated in the model of Parente and Prescott (1999) when the insiders derive utility from leisure, abstracting from this choice is restrictive.[18] So, why do we nonetheless abstract from hours worked? The first answer is that cross–country differences in hours worked would have to be unreasonably large to generate large cross–country differences

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[17]With this alternative specification there is there is too much synchronization between the choice of insider productivity and the marginal outsider product. The marginal outsider products determines at which b the outsiders enter.

[18]The intuition for the result of Cozzi and Palacios is straightforward. Both in the model of Parente and Prescott and in our model the coalitions restrict their sectors' outputs by choosing low insider productivities and no leisure. If in an extension with leisure, they were able to restrict the insider time worked, then they could restrict their sectors' outputs in more efficient way: choose a low insider working time and a maximal insider productivity. If leisure is a normal good, the latter strategy clearly dominates the former in terms of insider utility.

in per–capita income levels. The second answer is that even in those developed countries with the strongest labor unions, restrictions in the hours worked have proven to be difficult to achieve. Restricting hours worked should be yet more difficult in developing countries.

Finally, our results raise the question of why societies tolerate monopoly rights at the costs of substantial losses of income. Olson (1982) argues that if the costs of granting monopoly rights to each coalition are small, then lobbying will result in monopoly rights being granted. In recent work, Bridgeman et al. (2001) take up this argument in a model of lobbying and technology adoption and they construct equilibria in which monopoly rights are granted. The follow up question arises why society cannot buy out the coalitions through compensatory schemes. There are at least two answers to this question. First, Parente and Prescott (1999) argue that compensatory schemes are not time consistent: once a coalition has given up monopoly rights, society can tax away the transfers it paid to the coalitions or grant monopoly rights to new coalitions. Second, Kocherlakota (2001) shows that limited enforcement and sufficient inequality can imply that the allocation with monopoly rights is in fact constrained Pareto efficient, so a Pareto–improving compensatory scheme does not exist.

6   Conclusion

We have asked for which part of the observed cross–country differences in the level of per–capita income monopoly rights in the labor market can account. We have constructed a growth model in which monopoly rights permit insider coalitions to block the adoption of more efficient technologies or best–practice working arrangements. We have calibrated the model economy by assuming that the observed cross–country differences in the price of the non–tradable consumption good relative to capital goods come entirely from differences in the strength of monopoly in the intermediate good sector, which produce the input goods for the capital–producing manufacturing sector. We have found that monopoly rights can lead to quantitatively large reductions in the level of income. In particular, for our

baseline calibration, the per–capita income level with competition is by a factor 10.8 larger than that with monopoly rights. This is 4 times the difference of 2.7 found by Parente and Prescott (1999) for a model economy without capital. We have also found that the calibrated model is consistent with the observation that compared to rich countries, poor countries face higher prices of capital relative to consumption, invest smaller output shares in international prices, and have lower total factor productivity. The key to these findings is that monopoly rights in the intermediate goods sectors do not only reduce the insider productivity there, but also increase the relative price of capital and so reduce the capital–labor ratio in the whole economy.

Our paper is most closely related to Holmes and Schmitz (1995), Parente and Prescott (1999,2000), and Herrendorf and Teixeira (2002), which study monopoly rights in the labor market but abstract from capital. It is also related to the branch of the development literature that seeks to account for the observed cross-country differences in per–capita incomes under the assumption that the most productive technology and work practices are freely available once developed. In particular, Mankiw et al. (1992) emphasize the role of intangible capital, which increases the capital share; Chari et al. (1996), Eaton and Kortum (2001), and Restuccia and Urrutia (2001) emphasize the role of policy and trade distortions, which imply a higher relative price of capital; Parente et al. (2000) emphasize the role of home production, which leads to substantial non–measured income in poor countries; Acemoglu and Zilibotti (2001) emphasize the role of skill mismatch, which implies that the technologies developed in rich countries are not suited for poor countries; Schmitz (2001a) emphasizes the role of inefficient government production of investment goods; Acemoglu and Robinson (2002) emphasize the role of political elites, who lose power when technological change takes place; Garcia-Belenguer and Santos (2003) emphasize the role of human capital and externalities. We view these alternative explanations of differences in per–capita income levels as complementary to our own. Our results, nonetheless, distinguish monopoly rights by establishing quantitatively that they

can greatly reduce per–capita income levels.[19]

We end by suggesting several directions for future research. First, we have assumed that each insider coalition is small relative to the aggregate economy. While this is a natural starting point, several economies (those in Scandinavia for instance) have economy–wide labor coalitions. This is important because an economy–wide coalition will take into account the effects of its productivity choice on aggregate variables such as relative prices and the real interest rate, and should therefore block less. A challenging task is to formalize this idea. Second, the existing evidence is exclusively micro–evidence that shows how monopoly rights lead to the use of inefficient technologies and working arrangements at the firm or sector level; see for example Parente and Prescott (1999,2000), Holmes and Schmitz (2001a,b), and Schmitz (2001b). Our paper makes the clear prediction that the macro implications of monopoly rights should depend on the sectors in which they apply. In particular, monopoly rights should be most detrimental when they apply to the capital–producing sectors. We plan to explore whether this prediction is confirmed by the data. Finally, we have restricted our attention to a narrow concept of physical capital. Chari et al. (1996) showed that broadening the concept of capital by including human capital increases the income level differences that tax distortions generate. We plan to similarly extend the present model economy by including human capital and exploring whether this feature further magnifies the effects of monopoly rights on the levels of TFP and per–capita income.

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[19]The alternative explanations discussed in this paragraph all focus on income level differences. There is also a literature that studies how differences in institutional arrangements or policies affect growth rates. Recent examples are Hendricks (2000), who explores differences in equipment prices, Traca (2001), who explores differences in trade policy, and Edwards (2003), who explores differences in federal systems.

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Appendix

In this appendix, we divide all growing variables by γ^t to make them stationary. We indicate the stationary variables by a tilde, so $\widetilde{K}_t \equiv K_t/\gamma^t$ etc. To lighten the notation, we will moreover not write anymore that all variables depend on the states.

First–order Conditions

The first–order conditions to the individual problems are:

$$p_s \widetilde{s}_\iota = \alpha[(1 + r - \delta)\widetilde{k}_\iota + \widetilde{w}_\iota - \widetilde{k}'_\iota], \tag{14a}$$

$$p_m \widetilde{m}_\iota = (1 - \alpha)[(1 + r - \delta)\widetilde{k}_\iota + \widetilde{w}_\iota - \widetilde{k}'_\iota], \tag{14b}$$

$$\frac{\widetilde{s}_\iota^{\alpha(1-\rho)}}{p_m \widetilde{m}_\iota^{\rho+\alpha(1-\rho)}} = \beta(1 + r' - \delta)\frac{\widetilde{s}_\iota'^{\alpha(1-\rho)}}{p'_m \widetilde{m}_\iota'^{\rho+\alpha(1-\rho)}}. \tag{14c}$$

The first–order conditions to the problem of the representative firms in the service sector are:

$$r = p_s A\theta \left(\frac{\widetilde{k}_s}{l_s}\right)^{\theta-1}, \tag{15a}$$

$$\widetilde{w}_i \geq p_s A(1 - \theta)\left(\frac{\widetilde{k}_s}{l_s}\right)^{\theta}, \quad \text{``=" if } l_{si} > 0, \tag{15b}$$

$$\widetilde{w}_o = p_s A(1 - \theta)\left(\frac{\widetilde{k}_s}{l_s}\right)^{\theta}. \tag{15c}$$

Given that $p_m = \mu$, we can rewrite the problem of the representative firm in the manufacturing sector to:

$$\max_{\widetilde{z}_i} \left(\int_0^1 \widetilde{z}_i^{\frac{\sigma-1}{\sigma}} di\right)^{\frac{\sigma}{\sigma-1}} - \int_0^1 p_{z_i}\widetilde{z}_i di.$$

Therefore, the demand function for intermediate good $\widetilde{z}_i$ is given by:

$$\widetilde{z}_i = \frac{1}{p_{z_i}^{\sigma}}\left(\int_0^1 \widetilde{z}_i^{\frac{\sigma-1}{\sigma}} di\right)^{\frac{\sigma}{\sigma-1}}. \tag{15d}$$

Imposing zero profits gives:

$$1 = \int_0^1 p_{z_i}^{1-\sigma} di. \tag{15e}$$

The first–order conditions to the problem of the representative firm in the intermediate good sector are:

$$r = p_z \theta \left(\frac{\widetilde{k}_z}{l_z} \right)^{\theta-1}, \tag{15f}$$

$$\widetilde{w}_i = p_z (1-\theta) b \left(\frac{\widetilde{k}_z}{l_z} \right)^{\theta}, \tag{15g}$$

$$\widetilde{w}_o \geq p_z (1-\theta)(1-\omega) \left(\frac{\widetilde{k}_z}{l_z} \right)^{\theta}, \quad \text{``=" if } l_{so} > 0. \tag{15h}$$

Proof of Proposition of 1

$b = 1$ in BGP equilibrium

The problem of the representative insider coalition boils down to the problem of maximizing the next period's utility of its representative member. Recall that $l_{so} > 0$ and $l_{zi} > 0$ by assumption, so some outsiders labor must be allocated to the service sector and some insider labor must be allocated to the intermediate good sector.

We begin by showing that $b = 1$ is a BGP equilibrium strategy. If $b = 1$, then outsiders and insiders have the same marginal product in the intermediate good sector. Since they also have the same marginal product in the service sector, the wages in the service sector and the intermediate good sector must be the same. (If they were not, then all individuals would want to work in the sector with the higher wage, which is inconsistent with equilibrium.) Consider any deviation $b < 1$. Then the marginal outsider product in the intermediate good sector would be higher than that of the insiders. The first subcase would be that the outsiders are still indifferent between the service sector and the intermediate good sector. Since $l_{zi} > 0$ by assumption, some insiders would still work in the intermediate good sector. Since their marginal product there is smaller than that of the outsider, they would earn a lower wage than they could earn in the service sector. This is a contradiction. The second subcase would be that the outsider strictly prefer to work in the service sector. In this case, the insiders must be indifferent or prefer the

intermediate good sector. Since the insiders marginal product in the intermediate good sector is lower than that of the outsiders, this would imply that all outsiders would prefer the intermediate good sector too. This is a contradiction.

Market clearing

We start by noting that the equality of the wages and the equality of the real interest rates across sectors imply the quality of the capital–labor ratios, which, in turn, implies that $p_s A = 1$. This together with the Euler equations (14c) gives the capital–labor ratios along the BGP equilibrium:

$$\frac{\widetilde{K}}{2} = \frac{\widetilde{K}_s}{L_s} = \frac{\widetilde{K}_z}{L_z} = \left[\frac{\beta\theta}{\gamma^\rho - \beta(1-\delta)}\right]^{\frac{1}{1-\theta}}. \tag{16}$$

Applying Walras law, we only need to prove market clearing for the manufacturing sector. The supply of manufactured consumption goods is given by the production minus the BGP investment:

$$\frac{1}{\mu}\left[\widetilde{K}_z^\theta L_z^{1-\theta} + (1-\delta-\gamma)\widetilde{K}\right].$$

The demand for manufactured consumption goods is given by $(1-\alpha)/\mu$ times the income that is spent on consumption goods. Recalling that $p_s A = 1$, we have:

$$\frac{1-\alpha}{\mu}\left[\widetilde{K}_s^\theta L_s^{1-\theta} + \widetilde{K}_z^\theta L_z^{1-\theta} + (1-\delta-\gamma)\widetilde{K}\right].$$

Equalizing supply and demand and rearranging, we find:

$$\left(\frac{\widetilde{K}_z}{L_z}\right)^\theta L_z = (1-\alpha)\left[\left(\frac{\widetilde{K}_s}{L_s}\right)^\theta L_s + \left(\frac{\widetilde{K}_z}{L_z}\right)^\theta L_z\right] + \alpha(\gamma+\delta-1)\left(\frac{\widetilde{K}}{2}\right)2. \tag{17}$$

Using (16) and that $L_s + L_z = 2$, we obtain:

$$\frac{L_z}{2} = (1-\alpha) + \alpha(\gamma+\delta-1)\left(\frac{\widetilde{K}}{2}\right)^{1-\theta} = (1-\alpha) + \alpha\frac{\beta\theta(\gamma+\delta-1)}{\gamma^\rho + \beta(\delta-1)}.$$

Clearly, $L_z > 0$. To show that, in addition, $L_z < 2$, we need to show that

$$\frac{\beta\theta(\gamma + \delta - 1)}{\gamma^\rho + \beta(\delta - 1)} < 1.$$

This is equivalent to

$$\beta(1 - \delta)(1 - \theta) < \gamma^\rho(1 - \theta\beta\gamma^{1-\rho}).$$

Since we required that $\beta\gamma^{1-\rho} < 1$ and since $\beta(1 - \delta) < 1 \leq \gamma^\rho$, this inequality always holds.

Existence of unique value functions and a unique BGP equilibrium

The environment with deflated variables is stationary. It therefore satisfies the standard assumption that guarantee the existence of a unique value function and a unique BGP equilibrium; see Chapter 4 of Stokey and Lucas (1989). Along the BGP, $\widetilde{K}'_x = \widetilde{K}_x$ and $\widetilde{K}'_z = \widetilde{K}_z$, so K_x and K_z grow at rate $\gamma - 1$. Since b is constant, it follows that the quantities of all physical goods grow at rate $\gamma - 1$ too.

Proof of Proposition 2

$b = \underline{b}$ in BGP equilibrium

We start by deriving the semi reduced–forms of the wages. They will be functions of b, which the coalition chooses, of $\bar{l}_z$, which the coalition affects because it is a sector–wide average, and of $\widetilde{M}$, $\widetilde{X}$, and r, which the coalition does not affect because they are economy–wide averages.

Substituting (15f) into (15g) and (15h), we find that the insider and outsider wages can be written as:

$$\widetilde{w}_i = b(1 - \theta)p_z^{\frac{1}{1-\theta}}\left(\frac{\theta}{r}\right)^{\frac{\theta}{1-\theta}}, \tag{18a}$$

$$\widetilde{w}_o \geq (1 - \omega)(1 - \theta)p_z^{\frac{1}{1-\theta}}\left(\frac{\theta}{r}\right)^{\frac{\theta}{1-\theta}}. \tag{18b}$$

Since the coalition affects p_z, we need to eliminate it. To this end, combine the production function from (4) with (15d):

$$\widetilde{k}_z^{\theta}(\bar{l}_z)^{(1-\theta)} = p_z^{-\sigma}(\mu\widetilde{M} + \widetilde{X}),$$

implying that

$$p_z = \frac{(\mu\widetilde{M} + \widetilde{X})^{\frac{1}{\sigma}}}{\widetilde{k}_z^{\frac{\theta}{\sigma}} l_z^{\frac{1-\theta}{\sigma}}}. \tag{19}$$

Substituting this expression into (15f), we find:

$$\widetilde{k}_z = \left[\frac{\theta^{\sigma}(\mu\widetilde{M} + \widetilde{X})}{r^{\sigma}\bar{l}_z^{(1-\theta)(1-\sigma)}}\right]^{\frac{1}{\theta+\sigma(1-\theta)}}. \tag{20}$$

This expression together with (19) gives us the semi–reduced form for the relative price:

$$p_z = [\theta^{-\theta}(\mu\widetilde{M} + \widetilde{X})^{1-\theta}r^{\theta}\bar{l}_z)^{-(1-\theta)}]^{\frac{1}{\theta+\sigma(1-\theta)}}. \tag{21}$$

The semi–reduced forms for the wages result after substituting (21) into (18a) and (18b):

$$\widetilde{w}_i = b(1-\theta)\left[\frac{r^{\theta(1-\sigma)}(\mu\widetilde{M} + \widetilde{X})}{\theta^{\theta(1-\sigma)}\bar{l}_z}\right]^{\frac{1}{\theta+\sigma(1-\theta)}}, \tag{22a}$$

$$\widetilde{w}_o \geq (1-\omega)(1-\theta)\left[\frac{r^{\theta(1-\sigma)}(\mu\widetilde{M} + \widetilde{X})}{\theta^{\theta(1-\sigma)}\bar{l}_z}\right]^{\frac{1}{\theta+\sigma(1-\theta)}}. \tag{22b}$$

Denote by $\underline{b}$ the value of the productivity parameter b that clears markets and implies that the insiders strictly prefer the intermediate good sector and the outsiders are just indifferent. Now, we show that $\underline{b}$ is part of a BGP equilibrium, that is, deviating from it

does not increase the insider wage. At $b = \underline{b}$, (22a) and (22b) reduce to:

$$\widetilde{w}_i = \underline{b}^{-\frac{(1-\sigma)(1-\theta)}{\theta+\sigma(1-\theta)}}(1-\theta)\left[\frac{r^{\theta(1-\sigma)}(\mu\widetilde{M}+\widetilde{X})}{\theta^{\theta(1-\sigma)}}\right]^{\frac{1}{\theta+\sigma(1-\theta)}}, \tag{23a}$$

$$\widetilde{w}_o = \underline{b}^{\frac{-1}{\theta+\sigma(1-\theta)}}(1-\omega)(1-\theta)\left[\frac{r^{\theta(1-\sigma)}(\mu\widetilde{M}+\widetilde{X})}{\theta^{\theta(1-\sigma)}}\right]^{\frac{1}{\theta+\sigma(1-\theta)}}. \tag{23b}$$

We assume that the deviation is marginal so the insiders continue to prefer strictly the intermediate good sector. Consequently, insider labor continues to equal to one. (23a) shows that if the coalition increases b marginally, then $\widetilde{w}_i$ falls irrespective of how outsider labor reacts. If the coalition decreases b marginally, then $\widetilde{w}_i$ falls too. This follows because if outsider labor remained unchanged, then the right hand–side of (23b) would become larger than the service–sector wage $\widetilde{w}_o$. Since some outsiders must work in the service sector by assumption, outsiders labor in the intermediate good sector must go up until (22b) holds with equality. But then the $\widetilde{w}_i$ must fall.

$\underline{b}$ in each BGP equilibrium

We need to show that $\widetilde{\underline{b}} \in (1-\omega, 1)$ with $\widetilde{\underline{b}} \neq \underline{b}$ cannot be part of an equilibrium. Recall that at any equilibrium $\widetilde{\underline{b}}$ the outsiders cannot strictly prefer the intermediate good sector because outsider labor in the service sector is required to be positive. Thus, there are three subcases for $\widetilde{\underline{b}} \neq \underline{b}$: (i) the outsiders strictly prefer the service sector; (ii) the outsider are indifferent between the service sector and the intermediate good sector but outsider labor in the intermediate good is zero ("just indifferent"); (iii) the outsider are indifferent between the service sector and the intermediate good sector but outsider labor in the intermediate good sector is positive.

We start with subcase (i). If the insiders strictly prefer the intermediate good sector, then (23a) shows that the insider coalition can increase the insider wage by decreasing b. If the insiders are indifferent, then the insider wage is smaller than at $\underline{b}$ where the

insiders strictly prefer the intermediate good sector. Thus, $\widetilde{b} \neq \underline{b}$ cannot be part of an equilibrium.

We continue with subcase (ii). Again the insiders cannot be indifferent because then the insider wage would be smaller than at $\underline{b}$. Consequently the insiders must strictly prefer the intermediate good sector, (28) then implies that we are in the equilibrium characterized before: $\widetilde{b} = \underline{b}$.

We finish with subcase (iii). In this subcase (22b) must hold with equality and $l_{zo} > 0$. Again the insiders cannot be indifferent because then the insider wage would be smaller than at $\underline{b}$. Consequently the insiders must strictly prefer the intermediate good sector, so (22) with $l_{zi} = 1$ and $l_{zo} \in (0,1)$ applies. If the insider coalition increases b marginally, then the outsiders remain indifferent and (22b) remains unchanged. This implies that (22a) must increase. Thus, $\widetilde{b} \neq \underline{b}$ cannot be part of an equilibrium.

Market clearing

We start by noting that we cannot apply the proof for $\omega = 0$. The reason is that for $\omega = 0$, the coalition chooses $b = 1$ and l_z clears the market for manufactured goods. In contrast, in the postulated BGP equilibrium for $\omega > 0$ the outsiders are just indifferent between the service sector and the intermediate good sector, so we have $l_z = 1$ and $p_s A = (1 - \omega)^{1-\theta}$, so b must clear the market. To see that $p_s A = (1 - \omega)^{1-\theta}$, equalize the real returns on capital and on outsider labor across sectors:

$$p_s A \theta \widetilde{K}_s^{\theta-1} = \theta \widetilde{K}_z^{\theta-1} b^{1-\theta}, \tag{24a}$$

$$p_s A (1 - \theta) \widetilde{K}_s^{\theta} = (1 - \theta) \widetilde{K}_z^{\theta} (1 - \omega) b^{-\theta}, \tag{24b}$$

implying

$$\frac{\widetilde{K}_s}{\widetilde{K}_z} = \frac{1 - \omega}{b}. \tag{25}$$

Putting this equation back into (24), we obtain:

$$p_s A = (1 - \omega)^{1-\theta}. \tag{26}$$

We now find $b \in (0, 1)$ that clears the market. Using (25), (26), and the BGP conditions that the marginal products of the capital stocks in units of the z good are given by $\gamma^\rho \beta^{-1} + \delta - 1$, we obtain the same expression for the investment share as with competition. Moreover, we obtain the two BGP capital stocks:

$$\widetilde{K}_s = (1 - \omega) \left[\frac{\beta\theta}{\gamma^\rho + \beta(\delta - 1)} \right]^{\frac{1}{1-\theta}}, \tag{27a}$$

$$\widetilde{K}_z = b \left[\frac{\beta\theta}{\gamma^\rho + \beta(\delta - 1)} \right]^{\frac{1}{1-\theta}}. \tag{27b}$$

Due to Walras law, it is enough to prove market clearing for the manufacturing sector. The supply of manufactured consumption goods equals the total production plus the capital stock after depreciation minus the capital stock for next period. Along a BGP equilibrium with growth rate γ, this is given by

$$\frac{1}{\mu} \left[\widetilde{K}_z^\theta b^{1-\theta} + (1 - \delta - \gamma)\widetilde{K} \right].$$

The representative outsider and the representative insider spend shares $1 - \alpha$ of their disposable incomes on the manufactured consumption good. Using that the wage of the outsiders in the service sector equals their marginal product in the intermediate goods sectors, we obtain the demand for the manufactured consumption goods in period t:

$$\frac{1-\alpha}{\mu} \left\{ (1 - \theta)\widetilde{K}_z^\theta [(1 - \omega)b^{-\theta} + b^{1-\theta}] + \theta\widetilde{K}_z^{\theta-1} b^{1-\theta}\widetilde{K} + (1 - \delta - \gamma)\widetilde{K} \right\},$$

where we have used the fact that $\widetilde{M} = \widetilde{Z}$ in equilibrium. Equalizing supply and demand and using (27), we find that the market for the manufactured consumption good clears if

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and only if

$$\alpha\beta\theta(\gamma + \delta - 1)[1 + (1 - \omega)b^{-1}] = [\alpha - (1 - \alpha)(1 - \omega)b^{-1}][\gamma^\rho + \beta(\delta - 1)]. \qquad (28)$$

If there is a solution to this equation, then it is time independent. Condition (10a) ensures that the left–hand side is smaller than the right–hand side when $b = 1$; Condition (10b) ensures that the left–hand side is larger than the right–hand side when $b = 1 - \omega$. Thus, there is a constant market–clearing $\underline{b} \in (1 - \omega, 1)$ for which the outsiders are just indifferent and the insiders strictly prefer the intermediate good sector. The uniqueness of this $\underline{b}$ follows because both sides of (28) change monotonically and in opposite directions when b changes.

Existence of unique value functions and a unique BGP equilibrium

This part of the proof is exactly as in Proposition 1.

Proof of Proposition of 3

Parts (c) of Propositions 1 and 2 imply that p_s is smaller with monopoly than with competition and that p_s falls as ω increases.

Using (12), the investment share in output measured in domestic prices can be expressed as:

$$\frac{\delta(\widetilde{K}_s + \widetilde{K}_z)}{p_s \widetilde{K}_s^\theta L_s^{1-\theta} + \widetilde{K}_z^\theta L_z^{1-\theta}} = \frac{\delta}{p_s} \left(\frac{\widetilde{K}_s}{L_s} \right)^{1-\theta} = \frac{\beta\delta\theta}{\gamma^\rho + \beta(\delta - 1)}. \qquad (29)$$

Thus, the share in domestic prices is invariant to changes in ω. Denote the international price of services relative to capital by p_s^*. Note that for the monopoly economy $p_s^* > p_s$ and for the competition economy $p_s^* < p_s$. Consequently, with monopoly the investment share is smaller measured in international than in domestic prices; with competition the investment share is larger measured in international than in domestic prices. Moreover, since p_s falls as ω increases whereas p_s^* remains invariant, the investment share in international

prices falls as ω increases.

Parts (b) of Propositions 1 and 2 imply that b is smaller with monopoly than with competition. Thus, TFP in the intermediate good sectors is smaller with monopoly than with competition. The market clearing condition (28) implies that $(1-\omega)b^{-1}$ is constant. Hence, b and TFP in the intermediate good sectors fall as ω increases.

The Euler equations (12) and the fact that p_s and b are smaller with monopoly than with competition imply that the capital–labor ratios in all sectors are smaller with monopoly than with competition. Moreover, since p_s and b fall as ω increases, the capital–labor ratios of all sectors fall as ω increases. Since aggregate labor is constant, the aggregate capital stock must be smaller with competition than with monopoly and it must fall as ω increases. The Euler equations (12) imply that total output equals:

$$p_s\widetilde{K}_s^\theta L_s^{1-\theta} + \widetilde{K}_z^\theta L_z^{1-\theta} = \frac{\beta\theta}{\gamma^\rho + \beta(\delta - 1)}(\widetilde{K}_s + \widetilde{K}_z). \tag{30}$$

Thus, total output is smaller with monopoly than with competition and it falls as ω increases.

Definition (11) and (30) imply that aggregate TFP can be written as

$$\widetilde{TFP} = \frac{\beta\theta}{\gamma^\rho + \beta(\delta - 1)}\left(\frac{\widetilde{K}_s + \widetilde{K}_z}{2}\right)^{1-\theta}. \tag{31}$$

Thus, aggregate TFP is smaller with monopoly than with competition and it falls as ω increases.

Solving the Model with a Tax

We follow the same steps as in the proofs of Propositions 1 and 2. This yields $(1+\tau)p_s A = (1+\tau)p_z = p_m/\mu = p_x = 1$, Equation (17), and

$$\frac{\widetilde{K}}{2} = \frac{\widetilde{K}_s}{L_s} = \frac{\widetilde{K}_z}{L_z} = \left[\frac{p_z\beta\theta}{\gamma^\rho - \beta(1-\delta)}\right]^{\frac{1}{1-\theta}}.$$

Combining these equations, it is straightforward to compute the equilibrium quantities as functions of the tax rate.