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Managerial Versus Production Wages:  
Offshoring, Country Size and Endowments

by

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# Managerial Versus Production Wages: Offshoring, Country Size and Endowments\*

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## Abstract

We explore the role of trade in differentiated final goods as well offshoring of tasks for inequality both within and between countries. We emphasize the distinction between managerial and production labor. Managerial labor is a fixed input while production labor is a variable input. Following Grossman & Rossi-Hansberg (2010b) we assume that production labor is composed of tradable tasks, with “Marshallian” economies of scale on the task level. We first identify the key determinants of income distribution in a world where trade is restricted to final goods. We then allow for trade in production tasks, driven by country size as well as relative endowment with managerial and production labor. If the two countries are of equal size and if their relative endowments are not too different, then the task trading equilibrium features equalization of production wages, although the pattern of task trade and managerial wages are indeterminate. For differences in relative endowments beyond a certain threshold level, the trading equilibrium is unique and features one-way trade in line with comparative advantage. Relying on numerical simulations we show that international inequality is affected in a non-monotonic way by the cost of task trade. Comparing orders of magnitude we conclude that offshoring between similar countries only has a small positive effect on the managerial wage premium, compared to offshoring between countries with a different relative endowment.

JEL-Classification: F12, F16, F23

Keywords: Offshoring, Economies of Scale, Income Distribution, International Inequality

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# 1 Introduction

Explaining wages across individuals, countries and time is among the most important challenges for modern economics. Individuals want to know the wage they can expect when deciding about educational investment or about migration, and policy makers want to understand the causes of troublesome trends in income distribution within their countries as well as inequality and the lack of convergence between countries. This paper tries to contribute to our understanding of wage inequality within and between countries. We investigate two key determinants of wages: A country's endowment with managerial relative to production labor and the overall size of its labor force, relative to that of other countries.

Models of comparative advantage suggest that a country's factor endowment should play a very limited role for its factor prices, if the country is open. Indeed, the factor price equalization theorem tells us that under certain conditions it plays no role at all. Under these conditions, all countries' factor prices are determined by the world endowment, and not by their own national endowments. By the same token, countries that are open to trade become vulnerable to world endowment shocks. According to this logic, trade does away with *scarcity premia* earned by owners of a country's scarce resources, and the factor content of trade should tell us what openness does to a country's factor prices.<sup>1</sup> However, scarcity premia regain importance to the extent that trade leads to perfect specialization, in which case a national endowment change alters a country's output pattern, or equivalently, its "cone of diversification". Arguably, the advent of fragmentation and offshoring, by vastly increasing the number of "things" that are tradable, has increased the likelihood of complete specialization, thus contributing to the importance of endowment-based scarcity premia.<sup>2</sup>

Just as trade impacts on scarcity, it may also allow a country to overcome its limited size. Modern trade theory incorporates two forms of scale economies. A large class of models

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<sup>1</sup>See the discussion in Deardorff (2000), Krugman (2000), Leamer (2000), and Panagariya (2000).

<sup>2</sup>This relationship between the number of goods and the "likelihood" of factor price equalization has first become apparent in the "continuum of goods version" of the Heckscher-Ohlin model developed by Dornbusch, Fischer & Samuelson (1980), long before the debate on offshoring has started. For "continuum of tasks models" of offshoring, see Feenstra & Hanson (1997) and, more recently, Kohler (2004) and Grossman & Rossi-Hansberg (2008). In a model similar to Feenstra & Hanson (1997), Treffer & Zhu (2005) show that catching-up by less developed countries may entail a systematic effect towards increasing their skill premium.

focuses on production of differentiated intermediate inputs, assuming that it involves a fixed cost. This assumption constitutes scale economies that are *internal to the firm*. A larger resource base then allows a better exploitation of these economies, leading to a higher number and lower prices of intermediate inputs. This implies economies of scale operating through the market for intermediates, *external* to the final goods producer; see Ethier (1982a). With free trade in intermediates the scale effect is even *international* in scope; see Ethier (1979). In such a world, country size plays a role for the determination of wages only if trade is costly. Workers in large countries will then see a smaller share of their consumption basket inflated through trade-cost, which boosts their real wages. This is the well-known “home market effect”, first pointed out by Krugman (1980). A similar effect obtains for final goods producers using differentiated traded intermediate inputs. Models of new economic geography incorporate this mechanism as a force of agglomeration; see Fujita *et al.* (2001).

The second type of scale economies stems from non-pecuniary spill-over mechanisms that require proximity, or at least stop at country borders. Thus, they are external to the firm and *national* in scope. Such “Marshallian” scale economies have long been recognized as a potentially important source of specialization and trade. But they constitute a somewhat awkward case, because they entail a potential for multiple trading equilibria, driven by arbitrary, but self-fulfilling expectations that each firm may have about other firms’ behavior (see Matsuyama, 1991; Krugman, 1991).<sup>3</sup> In a recent paper, Grossman & Rossi-Hansberg (2010a) show that the scope for multiple equilibria is substantially reduced if firms are not atomistic. More specifically, if firms correctly anticipate the discrete output and productivity effects of setting out-of-equilibrium prices, then the pattern of trade is no longer indeterminate, but driven by underlying comparative advantage. It is obvious that country size should become an important determinant of international inequality, if there is trade based on Marshallian scale economies.

In this paper, we address wage inequality that is driven by both endowment based scarcity premia and country size. We depart from existing literature in several ways. First, as regards

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<sup>3</sup>As pointed out long ago by Graham (1923), trade based on this form of scale economies need not be beneficial to all countries, even under otherwise ideal conditions, since scale effects are an externality; see Ethier (1982a).

a country's endowment, we focus on the distinction between managerial and production labor. We do not rule out that management is associated with tasks that require more skills or education than production tasks. But it is not a key ingredient of our story. Indeed, our analysis should be interpreted as assuming that the distinction between managerial and production labor is orthogonal to the skill dimension.<sup>4</sup> We argue that the key characteristic that separates managerial from production labor has more to do with the type of scale economies involved than with the level of skills. We follow Rosen (1982) who argues that *managerial activities* are often characterized by inherent indivisibility and scale economies.<sup>5</sup> The managerial input represents the ability to organize and monitor an entire production process that leads to a certain differentiated good. We model this in a very simple way by defining managerial labor to be a fixed input. This constitutes scale economies that are internal to the firm.

In contrast, *production activities* take the form of a variable input. Scaling up the level of a production process typically requires that the firm scales up employment of production workers. Production activities require expertise to perform a potentially large number of different activities dictated by complex value added chains. This expertise often relates to narrowly defined tasks, rather than to the entire production process. We follow Grossman & Rossi-Hansberg (2010a) who argue that such expertise develops through concentration of certain tasks in certain regions or countries, and not through the scale of firms as such. In other words, production work as a variable input is likely to exhibit economies of scale that are a) external to the firm, b) are likely to be national in scope, and c) are arising at the level of numerous individual tasks.

Defining managerial labor as a fixed input and production work as a variable input constitutes a further, somewhat subtle departure from the literature. Trade models featuring

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<sup>4</sup>Thus, our approach to some extent also addresses the concern raised in recent public debates about managerial incomes not reflecting educational premia.

<sup>5</sup>In Rosen's own words: "*Management involves discrete and indivisible choices and commands, such as which goods to produce, in what varieties and volume, and how to produce them. Supervision insures that management directives are carried through at the production level. Indivisibilities inherent in management decisions are represented analytically as a form of total factor productivity improvement and, as such, imply a strong scale economy, not unlike a public good but limited to the confines of the firm. For example, the decision of which good to produce is largely independent of scale, applying equally well to a very large enterprise as to a very small one.*" (Rosen, 1982, p. 312). Rosen models wage determination based on a mechanism of self selection of individuals into production and managerial activities, respectively. We simplify by assuming managerial and production labor to be in fixed supply.

monopolistic competition typically assume what Horn (1983) has called a homothetic technology, meaning that the fixed and variable inputs of a production process rely on the same aggregate of primary factors. This assumption substantially reduces the role of country size for the explanation of inequality. Indeed, in assuming a single type of input, most of the “new” trade theory focusing on scale economies is completely silent about inequality. Obviously, our setup takes non-homotheticity to the extreme in that fixed and variable inputs draw on two distinct parts of the labor force. Economies of scale thus become an important element in the determination of inequality.

There are three recent papers that have addressed issues of inequality along lines similar to what we do in this paper. Manasse & Turrini (2001) introduce a variant of the Krugman (1980) model where the variable input relies on “raw” labor, while the fixed input is defined in terms of managing skills. Thus they similarly depart from homotheticity in technology. Higher managerial talent translates into final goods of higher quality, with an associated higher willingness to pay. Households have different levels of managerial skills, but each household also incorporates “raw” production work. Thus, inequality does not arise between production workers and managers, but between “raw” labor and managerial skills, both embodied in the same individual. In addition, they assume that firm size is exogenously fixed at the level of a single household, which rules out any role for country size in wage determination. The thrust of their analysis is a potentially convex dependence of an individual’s remuneration on the amount of her managerial skills, which may explain the skewness in income distributions observed in many countries.

In contrast to Manasse & Turrini (2001), size effects are at the heart of Epifani & Gancia (2008) who assume external scale economies that are international in scope along the lines of Ethier (1982b). As in this paper, the interest lies in country size effects on inequality within countries. However, they stick to the distinction between high-skilled and low-skilled workers, and they assume technology to be homothetic in the sense of Horn (1983). It turns out that for a closed economy country size works in favor of high-skilled labor, provided that i) the degree of external scale economies, based on the variety effect as indicated above, is larger for the high-skill-intensive industry than the low-skill-intensive industry, and ii) the elasticity of substitution in demand for goods of the two industries is larger than 1. Furthermore, what is

true for a closed economy becoming larger is also true for two or many economies becoming more integrated. Since the model implies that with trade all countries similarly reap the benefits from serving a larger (world) market, there is no role for country size to play in wage inequality across countries.

A recent paper by Egger & Kreickemeier (2010) shares our view that inequality should be addressed in terms of the distinction between managerial labor as a fixed input and production-labor as a variable input. As in Manasse & Turrini (2001), they assume households to be differently endowed with innate managing abilities. However, they assume that managerial talent delivers higher productivity of employed production-labor, instead of a higher quality of the product. Moreover, at the stage of production the managerial and production input, respectively, are delivered by distinct individuals, although *ex ante* any household has the capacity to be either a manager or a worker. Households select themselves into one or the other type of activity on the basis of expected production wages and managerial income in the form of operating profits. As a firm owner, a manager needs to employ workers subject to a fair wage constraint, whereby workers' notion of fairness involves the desire to participate in the firm's idiosyncratic operating profits, i.e., the income of the firm's manager. This installs a mechanism of compression between production and managerial wages, but this comes at the expense of unemployment as well as inequality within the group of otherwise identical workers, who end up being matched with differently talented managers. Importantly, although Egger & Kreickemeier (2010) do assume final goods production with differentiated intermediates, they rule out the above-mentioned external economies of scale. Among their conclusions they find that trade may increase inequality, both within the groups of managers and workers and between the two groups, at the same time as it increases unemployment.

Our point of departure in this paper is a recent contribution by Grossman & Rossi-Hansberg (2010b) who define production labor input as a continuum of tasks, whereby for each task workers are the more productive, the more often that task is performed within the country, independently of firm size. They demonstrate that this generates a rationale for trade in tasks between two similar countries, "similar" meaning that they share the same ratio of managerial and production-labor endowment. Relative *country size* determines the structure of trade in tasks as well as the equilibrium wage rate for production workers in one



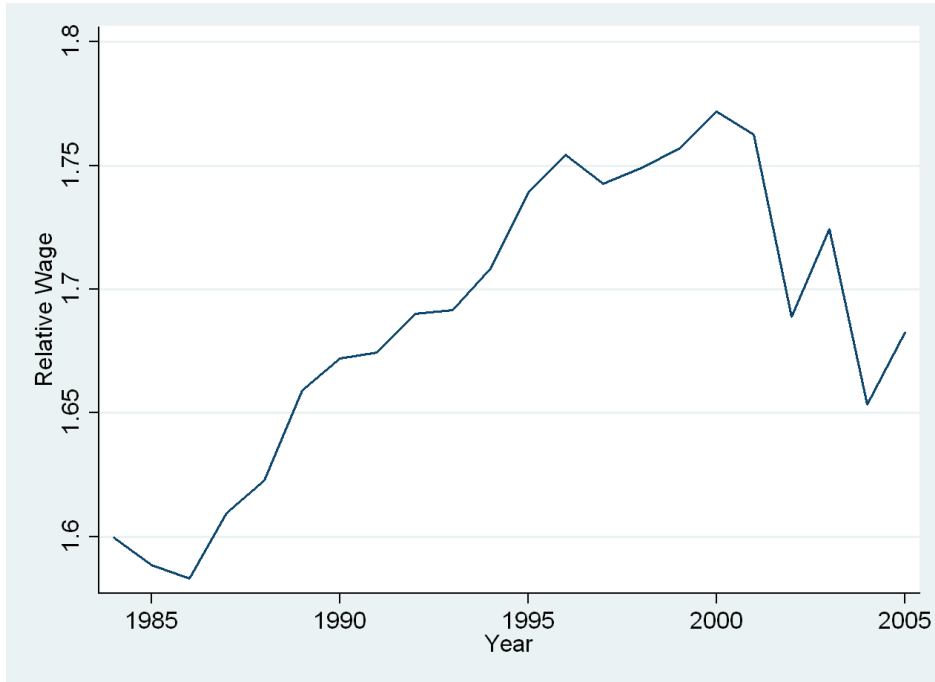
country relative to the other. In this paper, we extend the model developed by Grossman & Rossi-Hansberg (2010b) in allowing for *relative endowment differences* as well as country size. Moreover, in addition to cross country comparisons of production wages, we also address within-country inequality in terms of the *managerial wage premium* as well as *international inequality* in terms of income per capita. A detailed analysis of the influence of country size and relative endowments on these measures of inequality should enhance our understanding of the perennial issue of “trade and wages” as well as the issue of “international convergence and globalization”.

The paper is structured as follows. Section 2 looks at some stylized facts. Section 3 presents the key relationships of our model and derives comparative statics of size and endowments for the benchmark case of free trade in final goods, but no trade in tasks. In section 4, we derive the equilibrium conditions that govern trade in tasks. We discuss possible equilibrium locations of task performance. Since there are multiple trading equilibria that defy an analytical solution, section 5 proceeds with a numerical treatment that sheds light on how “freeness of task trade” affects the interaction between country size and relative endowments in determining managerial and production workers’ wages. Section 6 concludes the paper.

## 2 Empirical patterns of offshoring and inequality

We first want to look at trends in the managerial premium, i.e., the wages of managerial labor relative to production labor. Using data from the NBER productivity database for the US manufacturing sector, we identify managerial labor with nonproduction workers. In figure 1 we plot an index of wages wages paid to nonproduction workers relative to production workers for the period from 1984 to 2005, the latest period available. Beginning in 1987 in this figure we see a sharp increase in the managerial wage premium. However, after reaching a first peak in 1996 and it’s maximum in 2000, the wage premium has recently started to decline again, albeit with two brief hikes. Although this long-run trend cannot be seen as being determined by globalization alone, it is nonetheless interesting to note that the observed trend has not been monotonic. We shall return to this in our simulation exercise below.

Precise data on offshoring volumes are substantially more difficult to obtain. As a proxy,



**Figure 1.** Relative Wage of Nonproduction/Production Workers, US Manufacturing.  
*Source:* NBER productivity database (Bartelsman & Gray, 1996)

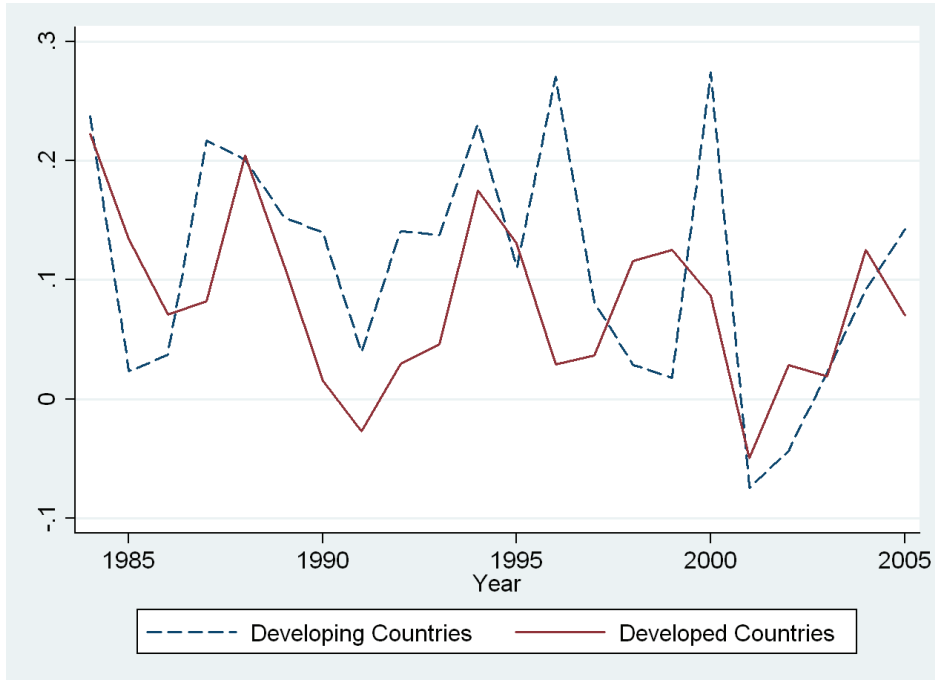
we use information from the Bureau of Economic Analysis on the US imports of goods from US majority-owned foreign affiliates. This data allows us to distinguish between offshoring between similar countries, i.e., between the US and other developed countries, and offshoring between the US and developing economies.<sup>6</sup> It can be seen from figure 2 that the periods of a rising wage premium for non-production workers since 1987 have been matched by high growth rates of offshoring with developing nations, whereas the growth rate of offshoring with developed economies has been substantially lower. At the same time, in 1997 and 2001/2002 when the increase in the wage premium stopped and finally reverted, the pattern of growth in offshoring was reversed. During these years, offshoring with developed countries was still growing as before<sup>7</sup>, while offshoring with developing nations was only growing marginally or even shrinking.

This is evidence that, in line with the theory outlined in Feenstra & Hanson (1997), it seems to be mainly offshoring of production tasks to production-labor-abundant developing

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<sup>6</sup>We define as developed economies the European countries, Canada, Japan, Australia, and New Zealand. Adding the Republic of Korea, Singapore, Taiwan, or South Africa does not change the picture significantly.

<sup>7</sup>In 2001 there was a negative growth of offshoring. However, that year is somehow an exception due to the economic disruptions in the aftermath of the dot-com bubble.



**Figure 2.** Growth Rates of Offshoring in Manufacturing Sector with Developed Countries and Developing Countries. *Source:* Bureau of Economic Analysis

countries that drives up the relative wage of US managers relative to production workers. In the following sections we describe a model that is more adequate to give predictions on this wage premium, since it does not rely on skill differences, but on innate differences of the two factors. Moreover the model allows for a distinct analysis of offshoring between a pair developed countries and offshoring between a pair of asymmetric countries. We show that this model yields more comprehensive results on relative wages than have been obtained in other papers.

### 3 Trade in final goods

We assume two countries, home and foreign (denoted by  $*$ ), sharing identical preferences and technology but differing in their exogenous endowments of managerial labor  $M$  ( $M^*$ ) and production workers  $L$  ( $L^*$ ). Both types of labor are immobile across countries. Preferences feature “love of variety”, modeled through a Dixit-Stiglitz-type utility function for symmetric varieties of a single final good. Producing any variety requires hiring  $f$  managers as a *fixed input*. In addition, production requires a *continuum of different tasks*, indexed by  $i \in [0, 1]$ , to

be performed by *production workers*. Firms are assumed to be headquartered in the country where they hire their managers. We make no distinction between firms hiring managers and managers setting up their own firm. In equilibrium, a manager must earn the same income, whether in terms of entrepreneurial profit, if self-employed, or through a perfect contract with a firm.

Given Dixit-Stiglitz preferences, final goods producers have price-setting power, and they charge a markup over marginal cost equal to  $\sigma/(\sigma - 1) > 1$ , where  $\sigma > 1$  is the elasticity of substitution between any two varieties of the good.<sup>8</sup> Assuming free entry, the number of firms is given by

$$n = M/f \quad \text{and} \quad n^* = M^*/f \quad (1)$$

and competitive managerial wages are determined from the condition that all profits end up in managerial income:

$$s = \frac{cx}{\sigma - 1} / f \quad \text{and} \quad s^* = \frac{c^*x^*}{\sigma - 1} / f \quad (2)$$

where  $c$  and  $c^*$  are marginal cost from production workers employed by a firm headquartered in the home and the foreign economy, respectively, with  $x$  and  $x^*$  denoting produced and sold quantities of their respective final-good-varieties.<sup>9</sup> We assume no trade costs for final goods, hence goods market equilibrium requires

$$\frac{x^*}{x} = \left( \frac{c^*}{c} \right)^{-\sigma} \quad (3)$$

We use  $1/A(i)$  to denote the amount of labor needed per unit of task  $i$ , if performed in the home economy, and analogously for the foreign economy. Due to external economies of scale, as argued in the introduction,  $A(i)$  depends on the entire amount of task  $i$  performed domestically, which we denote by  $X(i)$ . Following Grossman & Rossi-Hansberg (2010b), we model scale economies in constant elasticity form, such that  $A(i) = A[X(i)] := [X(i)]^\theta$ , with  $0 < \theta < 1$ . By analogy,  $A^*(i) = [X^*(i)]^\theta$ . Note that these scale economies, while *external*

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<sup>8</sup>This assumes a negligible influence of a single firm's pricing policy on the overall price index of varieties, which implies a sufficiently large number of firms and thus sufficiently large endowments  $M + M^*$ .

<sup>9</sup>Equations (2) follow from setting  $px - cx - sf = x[\sigma/(\sigma - 1) - 1]c - sf = 0$ . This replaces the zero-profit condition found in conventional models of monopolistic competition.

to the firm, do not extend beyond country borders; they are *national* in scope. The external nature of scale economies in production tasks is consistent with the assumption of perfect competition, if the institutional environment means that individual tasks are performed at arms length through market transactions.

We do not assume any cost asymmetry between organizational modes of task performance as such, but we require any equilibrium to be proof against firms' temptation to capture entire "task markets" by offering contracted task performance to all firms, either domestically or worldwide. When contemplating such "deviation", firms are assumed to pursue Bertrand price setting strategies which we shall describe in more detail below. Hence, the trading equilibria derived below are not perfect competition equilibria as in the canonical model of external scale economies. As we shall see, for this reason they also involve much less indeterminacy of the trade pattern.<sup>10</sup>

We now define  $\tilde{c}(w)$  as the unit cost function for a final good that arises for a firm headquartered in the home country, if trade is possible only for *final goods*, and analogously for  $\tilde{c}^*(w^*)$ . We use  $z(i)$  to denote the amount of task  $i$  that needs to be performed per unit of a final good. For simplicity, we assume that  $z(i)$  is uniform across the entire range of  $i$ , such that  $[z(i)]^{1-\theta} = z$ . Moreover, we assume that the entire amount of all tasks required per unit of the final good is of measure 1, meaning  $\int_0^1 z di = 1$ . This leads to

$$\tilde{c}(w) = w/A(nx) \quad \text{and} \quad \tilde{c}^*(w^*) = w^*/A(n^*x^*) \quad (4)$$

Given these assumptions,  $w/A(nx)$  and  $w^*/A(n^*x^*)$  may also be interpreted as the cost of performing a unit of any task, respectively, in the home and the foreign economy.

The labor market equilibrium for production workers requires

$$L = \frac{nx}{A[X(i)]} = (nx)^{1-\theta} \quad \text{and} \quad L^* = \frac{n^*x^*}{A[X^*(i)]} = (n^*x^*)^{1-\theta} \quad (5)$$

whereby the second equality in each line follows from the above assumption of external scale

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<sup>10</sup>See Grossman & Rossi-Hansberg (2010a) for a general treatment of trading equilibria with external scale economies and Bertrand price competition.

economies.<sup>11</sup> Choosing the foreign wage rate as our numéraire,  $w^* = 1$ , we obtain the foreign managerial wage premium as

$$\frac{s^*}{w^*} = s^* = \frac{L^*}{M^*(\sigma - 1)} \quad (6)$$

Given  $w^* = 1$ , the home wage is governed by commodity market clearing (3), which leads to  $w = (x/x^*)^{-1/\sigma} (xn)^\theta (x^*n^*)^{-\theta} = (x/x^*)^{\theta-1/\sigma} (n/n^*)^\theta$ . Taking into account equilibrium for production workers,  $x/x^* = (L/L^*)^{1/(1-\theta)} (n^*/n)$ , and using  $n^*/n = M^*/M$ , we arrive at

$$w = \left(\frac{M}{M^*}\right)^{1/\sigma} \left(\frac{L}{L^*}\right)^{(\theta\sigma-1)/[(1-\theta)\sigma]} \quad (7)$$

Substituting back gives  $s = w(nx)^{1-\theta} / M(\sigma - 1)$ , and we thus obtain

$$s = \frac{M^{*-1/\sigma} M^{1/\sigma-1} L^{*-(\theta\sigma-1)/[(1-\theta)\sigma]} L^{(\sigma-1)/[(1-\theta)\sigma]}}{\sigma - 1} \quad (8)$$

and the managerial wage premium in the home economy is given by

$$\frac{s}{w} = \frac{L}{M(\sigma - 1)} \quad (9)$$

This will be our measure of within-country inequality in the subsequent analysis. In addition, we look at cross-country inequality in terms of income per head in the home, relative to the foreign economy. This measure may be written as

$$R := \frac{s\theta_M + w\theta_L}{s^*\theta_{M^*} + w^*\theta_{L^*}} = \frac{M^* + L^*}{M + L} \cdot (M/M^*)^{1/\sigma} (L/L^*)^{\frac{\sigma-1}{(1-\theta)\sigma}} \quad (10)$$

where  $\theta_M = M/(M + L)$  is the share of managers in the home economy, and equivalently for all other shares.

**Size effect:** When looking at size effects, we vary the overall population of one country keeping the other country's population constant. Remember that the two types of labor are in different positions with respect to economies of scale. The scale effect from the fixed

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<sup>11</sup>It is perhaps worth pointing out that these scale economies do not translate into scale economies on the final goods level. Final goods producers do not act under the belief that increasing their output lowers marginal cost on account of a larger task performance. They take marginal cost  $c$  and  $c^*$  as given parametrically.

managerial input is internal to firms producing final goods, while the scale economies in production tasks are external to firms in production of certain tasks. This fundamental asymmetry notwithstanding, the benefit from a balanced increase in a country's labor force trickles down in equal proportions to both types of labor. This is seen for the home and foreign economy from (9) and (6), respectively. The managerial wage premium is independent of country size and depends only on relative endowments. A cross country comparison of incomes leads to a similarly clear cut result. Letting relative changes  $\hat{M} := dM/M = \hat{L} := dL/L$ , we have

$$\left. \frac{\hat{R}}{\hat{M}} \right|_{\hat{L}=\hat{M}} = -\frac{\theta}{\sigma(1-\theta)} + \frac{\theta}{1-\theta} > 0 \quad (11)$$

The first term is a negative terms of trade effect. Even though both factors grow at the same rate, output of each variety increases due to the economies of scale. The higher output is absorbed by consumers only if accompanied by a decline in the relative price of the domestic varieties. The second term is the direct effect on productivity, which is clearly positive and larger than the first term. The home economy therefore unambiguously gains from balanced growth of the labor force.

**Composition effect:** Considering an unbalanced growth of the labor force we see that the managerial wage premium decreases with an increase in the endowment of managers  $\widehat{s/w} = -\hat{M}$ . The intuition is straightforward. More managers raise the number of home firms at the expense of lower firm output. An increased scarcity of each home variety, relative to foreign varieties, implies that each home firm charges a higher price and, thus, pays a higher wage to its production workers. To summarize, a larger endowment of managers has a negative own-effect and a positive cross-effect on wages. By complete analogy, we have  $\widehat{s/w} = \hat{L}$ . On the other hand, while production workers clearly lose relative to managers, they might still gain in absolute terms, if scale economies are sufficiently strong and substitutability between varieties is sufficiently high; see (7).

Turning to cross-country inequality, we find an ambiguous result:

$$\frac{\hat{R}}{\hat{M}} = \frac{1}{\sigma} - \theta_M \quad (12)$$

Since each domestic firm reduces its output, market clearing implies a higher price of domestic varieties, depending on the elasticity of substitution. This constitutes a terms of trade improvement which works against the foreign economy. At the same time, each manager now employs less workers, which reduces her salary in terms of a residual claim. This works against domestic income per head, in line with the share of managers in the domestic labor force. A similar ambiguity arises for a change in production-labor endowment. We obtain

$$\frac{\hat{R}}{\hat{L}} = -\frac{1}{\sigma(1-\theta)} + \frac{\theta}{1-\theta} + \theta_M \quad (13)$$

The first term again indicates a terms of trade effect, which is negative due to higher output per firm, and which is reinforced by a higher productivity due to external scale economies. The negative effect on the terms of trade is now more pronounced than in the case of symmetric changes, since the number of varieties remains constant. The second term captures the income effect derived from higher productivity, which dominates the terms of trade, provided the degree of returns to scale is sufficiently large:  $\theta > 1/\sigma$ . The final term is readily interpreted as the effect on managers' salary which now is positive, since each manager employs more production workers. We summarize these findings in two propositions as follows:

**Proposition 1** (symmetric endowment changes). *Countries increasing in size, with the labor force composition unchanged, experience a rise in their income per capita relative to the rest of the world. A negative terms of trade effect is dominated by a positive productivity effect from external economies of scale in production-labor.*

**Proposition 2** (asymmetric endowment changes). *An asymmetric endowment increase additionally entails a labor force composition effect. It is positive if managers can employ a higher number of production workers and negative in the opposite case, whereby the strength of the composition effect depends on the initial degree of asymmetry. a) For an increase in production-labor, the terms of trade effect is negative and need not be dominated by a positive productivity effect. b) For an increase in managerial labor, the terms of trade effect is positive. The productivity effect vanishes. In either case the overall effect is ambiguous.*

All of these *relative wage* effects may be interpreted as *relative welfare* effects for the respective group of workers, provided that trade in final goods is free and costless, as assumed.



Consumers in both countries then pay identical prices for final goods, and they also face the same degree of variety. However, one needs to be cautious when considering absolute levels of *real* wages. Two additional channels need to be taken into account for real wages. The first is a change in variety that follows from any change in a country's endowment of managers; see the managerial labor market equilibrium condition (1) above. With "love for variety", such changes are of direct relevance for real wages. The second channel runs through final goods prices, which are related to marginal cost through a constant markup. From (4) and (5), marginal costs in the home and the foreign economy are related to endowment changes according to

$$\widehat{c} = \widehat{w} - \theta \widehat{L}/(1 - \theta) \quad \text{and} \quad \widehat{c}^* = -\theta \widehat{L}^*/(1 - \theta) \quad (14)$$

Based on these considerations, it is relatively straightforward to extend the above analysis to real wages. For instance, using to denote the exact price index dual to our (symmetric) Dixit-Stiglitz preferences,  $P := (Mp^{1-\sigma} + M^*p^{*1-\sigma})^{1/(1-\sigma)}$ , and  $w_r := w/P$  to denote the real production wage, we obtain

$$\widehat{w}_r = \frac{1}{\sigma} \left( 1 + \frac{\gamma}{\sigma - 1} \right) \widehat{M} + \frac{1}{\sigma(1 - \theta)} \left( \theta\sigma - 1 + \frac{\gamma}{\sigma} \right) \widehat{L} \quad (15)$$

By complete analogy, endowment changes entail a change in real manager income according to

$$\widehat{s}_r = \frac{1}{\sigma} \left( 1 - \sigma + \frac{\gamma}{\sigma - 1} \right) \widehat{M} + \frac{1}{1 - \theta} (\sigma - 1 + \gamma) \widehat{L} \quad (16)$$

In these equations, the term  $\gamma := M(p/P)^{1-\sigma} > 0$  is equal to the share of a domestic manager's income that is spent on domestic varieties. We conclude that the effect on the own remuneration are generally unambiguous, while the cross effects are always unambiguously positive. For example, a production worker will experience a welfare increase given an increase in  $L$  if and only if varieties are close enough substitutes, meaning that the terms of trade effect from a larger domestic work force is low, while the degree of scale economies is sufficiently large. A sufficient condition is that  $\theta > (1 - \gamma/\sigma)/\sigma$ ; notice that  $\gamma/\sigma < 1$ . The corresponding condition for the real income of a domestic manager is  $\gamma > (\sigma - 1)^2$ . Note that the terms of trade effect in this case is positive, since with an unchanged production work force a larger number of domestic managers means lower domestic output per variety and thus a higher

price per variety on the world market.

## 4 Trade in production tasks

In line with the literature, we assume that performing a certain task  $i$  outside the country of a firm's headquarter requires an additional amount of labor by a factor  $\beta t(i)$ . The additional labor required is labor from the country where the task is located, not where the headquarter is located. Naturally, we have  $\beta t(i) \geq 1$ , and we order tasks according to the ease with which they can be dislocated, whence  $t'(i) > 0$ . With this specification, tasks indexed at the bottom end of the interval  $[0, 1]$  are natural "first candidates" for concentrated performance in either the home or the foreign economy.

Let  $Q(\mathcal{H}) := \int_{i \in \mathcal{H}} z(i) di$  denote the Lebesgue measure of tasks concentrated in the home economy and analogously for tasks concentrated in the foreign country  $\mathcal{F}$ . Tasks performed domestically by firms in both countries are denoted by  $\mathcal{B}$ . The conditions that govern these three sets will be described in more detail below. This allows us rewrite the marginal cost for a final good in the home and foreign economies, respectively, as

$$c = \frac{wQ(\mathcal{H})}{(nx + n^*x^*)^\theta} + \frac{w^*T(\mathcal{F})}{(nx + n^*x^*)^\theta} + \frac{wQ(\mathcal{B})}{(nx)^\theta} \quad (17)$$

$$\text{and } c^* = \frac{wT(\mathcal{H})}{(nx + n^*x^*)^\theta} + \frac{w^*Q(\mathcal{F})}{(nx + n^*x^*)^\theta} + \frac{w^*Q(\mathcal{B})}{(n^*x^*)^\theta} \quad (18)$$

In these expressions  $T(\cdot)$  denotes the Lebesgue-measure of tasks augmented by the cost of trade, such that  $T(\mathcal{F}) := Q(\mathcal{F}) + \int_{i \in \mathcal{F}} \beta [1 - t(i)] z(i) di$ . In what follows we shall occasionally use  $t(\mathcal{F}) := T(\mathcal{F}) - Q(\mathcal{F})$ . An Analogous expression holds for the set of home-concentrated tasks  $\mathcal{H}$ . The full employment conditions for production labor can now be written as

$$L = \frac{nxQ(\mathcal{H})}{(nx + n^*x^*)^\theta} + \frac{n^*x^*T(\mathcal{H})}{(nx + n^*x^*)^\theta} + \frac{nxQ(\mathcal{B})}{(nx)^\theta} \quad (19)$$

$$\text{and } L^* = \frac{nxT(\mathcal{F})}{(nx + n^*x^*)^\theta} + \frac{n^*x^*Q(\mathcal{F})}{(nx + n^*x^*)^\theta} + \frac{n^*x^*Q(\mathcal{B})}{(n^*x^*)^\theta} \quad (20)$$

Note that our scaling assumptions imply  $Q(\mathcal{H}) + Q(\mathcal{F}) + Q(\mathcal{B}) = 1$ , which allows us to rewrite

the marginal cost equations as

$$c = \frac{w}{a} \left[ 1 + (\alpha - 1) Q(\mathcal{H}) + \left( \frac{w^* \alpha}{w} - 1 \right) Q(\mathcal{F}) + \frac{w^* \alpha}{w} t(\mathcal{F}) \right] \quad (21)$$

$$\text{and } c^* = \frac{w^*}{a^*} \left[ 1 + (\alpha^* - 1) Q(\mathcal{H}) + \left( \frac{w \alpha^*}{w^*} - 1 \right) Q(\mathcal{H}) + \frac{w \alpha^*}{w^*} t(\mathcal{H}) \right] \quad (22)$$

In these expressions, we defined the labor requirement coefficients  $a := (nx)^\theta$ ,  $a^* := (n^*x^*)^\theta$ , and  $A := (nx + n^*x^*)^\theta$  whereas the relative productivity of performing non-concentrated tasks with respect to concentrated tasks as  $\alpha := a/A \leq 1$  and  $\alpha^* := a^*/A \leq 1$ .

The terms in the square brackets are savings factors that represent the cost advantage from task trade. Note that without task trade we have  $c = w/a$  and  $c^* = w^*/a^*$ . Moreover, from the underlying assumption that  $t' > 0$  we have  $1 + Q(\mathcal{F})/t(\mathcal{F}) < w\alpha^*/w^*$ , and an analogous condition holds for tasks concentrated in the home economy. This condition means that a country's average relative advantage over a set of tasks concentrated there is always larger than the relative advantage at the cutoff task. Hence the bracketed savings factors are indeed smaller than 1. They correspond to the *productivity effect* in Grossman & Rossi-Hansberg (2008).

In a similar fashion, we may write the full employment conditions as

$$L = \frac{nx}{a} \left[ 1 + (\alpha - 1) Q(\mathcal{H}) + \alpha^{\frac{\theta-1}{\theta}} \alpha^{*\frac{1}{\theta}} [Q(\mathcal{H}) + t(\mathcal{H})] - Q(\mathcal{F}) \right] \quad (23)$$

$$\text{and } L^* = \frac{n^*x^*}{a^*} \left[ 1 + (\alpha^* - 1) Q(\mathcal{F}) + \alpha^{*\frac{\theta-1}{\theta}} \alpha^{\frac{1}{\theta}} [Q(\mathcal{F}) + t(\mathcal{F})] - Q(\mathcal{H}) \right] \quad (24)$$

Note that without task trade we have  $L = nx/a = (nx)^{1-\theta}$  and  $L^* = n^*x^*/a^* = (n^*x^*)^{1-\theta}$ . It is relatively obvious that the bracketed terms above represent the savings in production labor that derive from specializing in task trade. Thus, the term  $(\alpha - 1) Q(\mathcal{H}) \leq 0$  represents the scale effect from specialization over the set of tasks concentrated domestically. The term  $\alpha^{\frac{\theta-1}{\theta}} \alpha^{*\frac{1}{\theta}} [Q(\mathcal{H}) + t(\mathcal{H})]$  denotes the domestic resource use for home's task exports to foreign, relative to the absorption of domestic production labor embodied in that same measure of tasks  $\mathcal{H}$ , if produced domestically and for domestic use only. The final term then represents the production labor that would be required in order to perform domestically (and for domestic use only) the measure of tasks that are in fact offshored to the foreign economy. Thus, the

bracketed terms may be interpreted as the analogues to what Grossman & Rossi-Hansberg (2008) have called the *supply effect* of offshoring. If this term is smaller than one the labor supply effect is positive. This condition can be rewritten for the home economy as

$$Q(\mathcal{F}) > (\alpha - 1)Q(\mathcal{H}) + \alpha^{\frac{\theta-1}{\theta}} \alpha^{*\frac{1}{\theta}} [Q(\mathcal{H}) + t(\mathcal{H})] \quad (25)$$

and equivalently for the foreign economy. A positive labor supply effect for the home economy is likely to occur, if it is relatively small compared to the foreign economy and if offshoring costs are relatively low. Note that when there are no tasks concentrated in the home economy the right-hand side of the above equation reduces to zero, which implies a positive supply effect. In section 4.2 we shall derive conditions under which such a one-way task trade pattern emerges as a unique equilibrium with asymmetric relative endowments of the two countries with managers and production labor.

#### 4.1 Countries with equal relative endowments

**Outsourcing and deviant behavior:** When considering the location of task performance, a firm faces two decisions. The first is whether to locate a task in the home or the foreign economy. The second is whether to operate the task only for its own internal need or to aim at performing the task on a larger scale through outsourcing contracts with other firms. Such outsourcing relationships, in turn, raise two issues. First, since firms produce different varieties, tasks may be specific to varieties and, thus, relationship-specific. As emphasized by Antràs (2003) and Antràs & Helpman (2004), this may generate a hold-up problem, if complete and enforceable contracts cannot be written. For the sake of simplicity, we rule this out. The second issue relates to pricing. We assume that firms consider creating and capturing “task markets” for a whole country, or indeed the entire world, through Bertrand price competition. In this model, capturing a task market means offering task prices that undercut the costs of “in house” provision of tasks that firms in a given country or worldwide, respectively, face in some reference case of task locations.<sup>12</sup>

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<sup>12</sup>Note that “in house” does not mean that the task is located in the headquarter country. It means that a firm operates the task only for its own need.

For instance, in a case where all firms locate a certain task  $i$  in the home economy, any one firm might consider a deviant strategy of locating this task in the foreign economy and offering to perform this task for all foreign firms via outsourcing contracts. Grossman & Rossi-Hansberg (2010b) call this *local deviation* from home concentration. If the firm captures the entire foreign market for task  $i$ , it has a cost equal to  $w^*/A(n^*x^*)$ . To do so, it has to charge foreign firms a price just an  $\varepsilon$  below  $\beta t(i)w/A(nx + n^*x^*)$ , which is what they pay for this task in the reference case of home concentration. The deviant forgoes global scale, but has the advantage of avoiding the cost of offshoring when serving other foreign firms. We define  $I$  as the value of  $i$  which marks indifference between home concentration and local deviation towards catering for *foreign firms*. A completely analogous condition determines an indifference value  $I^*$  for indifference between foreign concentration and local deviation towards outsourcing relationships with *home firms*. These “cutoff-values” are implicitly determined by the conditions

$$\beta t(I) = \frac{w^*/A(n^*x^*)}{w/A(nx + n^*x^*)} \quad \text{and} \quad \beta t(I^*) = \frac{w/A(nx)}{w^*/A(n^*x^*)} \quad (26)$$

A pattern of task locations is an equilibrium only if such local deviation strategies are unprofitable. Equilibrium thus requires that tasks  $i > \max(I, I^*)$  be located at the respective firms’ headquarter location. Firms know that it does not pay to concentrate these tasks in any of the two countries, hence a deviant strategy is ruled out by definition. In other words, such tasks are immune against concentration. Conversely, for tasks  $i < \min(I, I^*)$  equilibrium is consistent with concentration in either the home or the foreign country. Either type of concentration is immune to local deviation. Thus, considering only local deviation strategies it seems that for these tasks the equilibrium pattern of task trade is not uniquely determined. If  $I^* < I$ , then concentration of tasks  $i \in [I^*, I]$  in the home economy is immune to local deviation, while foreign concentration isn’t. Conversely for tasks  $i \in [I, I^*]$  if  $I < I^*$  firms face a clear incentive to locate such tasks in the foreign economy.<sup>13</sup>

However, firms may also consider deviation strategies on a larger scale, such that the

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<sup>13</sup>It is irrelevant whether this location is chosen as a deviation strategy, i.e., under the (false) belief that all other firms still locate these tasks at home, or chosen in the belief that all firms act alike.

deviant firm tries to attract task demand from the *entire world*. Grossman & Rossi-Hansberg (2010b) call this *global deviation*. Task locations that are immune to local deviation in both countries may still be open to global deviation. Consider an equilibrium where all firms locate their capacity of performing task  $i < \min(I^*, I)$  in the *home* economy. The cost of obtaining this task is then equal to  $w/A(nx + n^*x^*)$  for home firms and  $\beta t(i)w/A(nx + n^*x^*)$  for foreign firms. Now consider a *deviant firm* setting up task- $i$  capacity in the *foreign* economy and trying to make a profit by selling this task for just an  $\varepsilon$  below their respective production cost to the two types of firms. It has production costs equal to  $w^*/A(nx + n^*x^*)$  plus offshoring costs of serving home firms. To capture the entire world market for task  $i$ , the deviant would have to charge foreign firms at a price  $\beta t(i)w/A(nx + n^*x^*) - \varepsilon$ , while charging  $w/A(nx + n^*x^*) - \varepsilon$  to home firms.

Given this pricing strategy, the profit obtained from such global deviation from a concentration of any task  $i < \min(I^*, I)$  in the home economy emerges as

$$\pi_d(i) := \frac{w[nx + \beta t(i)n^*x^*] - w^*[n^*x^* + \beta t(i)nx]}{A(nx + n^*x^*)} \quad (27)$$

To proceed, we now define a task  $J$  that yields a zero profit for the deviant firm, which means  $\pi_d(J) = 0$ . This condition can be written as

$$\beta t(J)(wn^*x^* - w^*nx) = w^*n^*x^* - wnx \quad (28)$$

$$\text{or } \beta t(J) = \frac{w^*n^*x^* - wnx}{wn^*x^* - w^*nx} \quad (29)$$

**Equilibrium pattern of task trade:** Suppose there is a solution to (29) with  $J \in ]0, 1[$ . Suppose, moreover, that  $J < \min(I, I^*)$ . Then, the right-hand side of (29) must have equal signs for the denominator and the numerator. If it is negative, essentially meaning that the home economy is larger than the foreign economy, then it must be true that  $\pi_d(i) > 0$  for  $i < J$ , and conversely for  $i > J$ . In the opposite case of a smaller home economy, the deviant's profit is positive for  $i > J$  and negative for  $i < J$ .

Let us look at the first of these cases where the home economy is relatively large. Obviously, for tasks  $i > J$  and  $i < \min(I, I^*)$ , meeting world-wide demand for the task from concentrating

all capacity in the home economy is immune to global deviation. The same is not true for tasks  $i < J$ . But let us assume that firms can relocate their own production capacity at no cost. Then, any attempt by the deviant with a foreign production base to charge foreign firms a price above their own task cost  $w^*/A(nx + n^*x^*)$  would be futile, since these firms would then be prompted to relocate to a foreign production base. The important point to bear in mind here is that these firms would fully benefit from size advantage, since by assumption that advantage is external to the firm. Consequently, the deviant's positive profit would then rely on charging home firms a price above  $\beta t(i)w^*/A(nx + n^*x^*)$ . But again, such an attempt would be frustrated by home firms shifting their production base for task  $i$  to the smaller foreign economy. Hence, global deviation from coordinated domestic concentration of tasks  $i < J$  in the end does not lead to any outsourcing.<sup>14</sup> What it does, instead, is tie down the location of tasks  $i < J$  to the smaller of the two countries, which in our argument is the foreign economy, and of tasks  $i > J$  and  $i < \min(I, I^*)$  in the home economy. It is relatively obvious that a perfectly analogous reasoning leads to concentration of all tasks  $i > J$  and  $i < \min(I, I^*)$  in the foreign economy, provided that it is the larger of the two economies. If instead  $J > \min(I, I^*)$  the above argument still applies for tasks  $i < \min(I, I^*) < J$ , while the location of tasks in the range between  $I$  and  $I^*$  is pinned down by the argument of local deviation only, and for tasks  $i > \max(I, I^*)$  decentralized location is the only equilibrium outcome, as we have seen above.

Following Grossman & Rossi-Hansberg (2010b), we are now able to fully describe the pattern of task trade between two countries that differ only in size. We have five different possibilities separated by whether  $I > I^*$  or  $I^* < I$  and by whether or not  $J < \min(I, I^*)$ . In all of these cases, tasks with low offshoring costs are concentrated in the low-wage country, which is also the smaller of the two countries. Tasks with intermediate offshoring costs are

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<sup>14</sup>More precisely, final goods producers are indifferent between in-house procurement of tasks and outsourcing, but the location of task capacity is unambiguous. An alternative narrative for such an equilibrium is that ex ante all firms are enticed, independently of each other, into such a deviation strategy. But by definition of deviation, if all firms behave alike, such a strategy is impossible. Having followed what they individually perceive as a deviation strategy, firms will ex post find out that "in house" task performance is the best that they can do. Note also that with a continuum of tasks, each individual task performance will always be "small" relative to the resource base of any one of the two economies. In a case with but two tasks we could not rule out that a deviation strategy is negated because an economy does not have enough resources; see Grossman & Rossi-Hansberg (2010a) for a thorough discussion of this issue.

concentrated in the larger country. And tasks at the upper end of the scale of offshoring costs are performed in a decentralized way, with each firm locating its task capacity in its headquarters country. However, note that each of these sets of tasks might be empty. Grossman & Rossi-Hansberg (2010b) show that in such an equilibrium wages and aggregate output always go hand in hand. In other words, the high-wage country will always have a higher aggregate output than the low-wage country. Intuitively, for most parameter values, the country that is endowed with a higher amount of both factors of production will obtain a higher aggregate output. However, with low offshoring costs and the two countries being sufficiently equal, three equilibria are possible: The second equilibrium has the smaller country achieving a *higher* aggregate output and therefore a *higher* wage for production workers. In the third equilibrium both countries have an equal aggregate output as well as equal wages, and the pattern of task trade cannot be determined.

## 4.2 Task trade with different endowment proportions

Grossman & Rossi-Hansberg (2010) focus on country size effects, assuming *symmetry* in *relative* endowments. An important purpose of this paper is to explore *asymmetry* in *relative* endowments with production and managerial labor. We anchor our comparisons in two ways. First, without loss of generality we assume  $L/M = 1$  as well as  $M^* = 1$ , so that asymmetry is driven by a variation in  $L^*$ . Obviously, such a variation also implies a variation in size. In order to sharpen our focus on relative endowment differences, we therefore let  $L$  and  $M$  vary in equal proportions to neutralize size effects deriving from variations in  $L^*$ . Size effects are, in turn, driven by  $nx$  and  $n^*x^*$ , hence we impose the condition  $nx = n^*x^*$ . This must be interpreted as a “recalibration condition” which endogenously determines the size of the domestic economy so as to neutralize the size effect deriving from variations in  $L^*$ . Given these anchoring assumptions, the relative endowment asymmetry may be measured by  $L^*/L$ . The relationship between endowment asymmetry and task trade as well as wages can be summarized by the following proposition.

**Proposition 3** (task trade with different endowment proportions). *If the two countries feature different endowment proportions,  $L^*/M^* \neq L/M$ , and if absolute endowment levels are anchored as described above such that external scale effects are neutralized across countries,*



then there are three types of equilibria. (a) If the endowment difference is above a certain threshold level,  $L^*/L > \Lambda$ , then the equilibrium features one-way task trade, with a concentration of low-cost tasks in the country with the larger endowment of production labor relative to managerial labor. (b) If  $L^*/L = \Lambda$ , then production wages are equalized in the resulting equilibrium  $w^* = w$ , and the task trade pattern is determined as above. (c) If  $L^*/L < \Lambda$ , then a task trade equilibrium features equalization of production wages,  $w^* = w$ , whereby the pattern of task trade is indeterminate, as is the managerial wage rate in either country.

We proof this proposition by first looking at an equilibrium where the level of offshoring is zero,  $I = I^* = 0$ , due to a high enough value of  $\beta$ . In this equilibrium, either type of task concentration is negated by the profitability of local deviation; see (26). Without loss of generality, we assume that the relative endowment difference is such that  $L^*/M^* > L/M$ . Denoting the equilibrium wages in a no-offshoring-equilibrium by  $w_0^*$  and  $w_0$ , respectively, we know from above that this implies  $w_0^* < w_0$  in the initial zero-offshoring-equilibrium. Now suppose that  $\beta$  falls in a continuous fashion, eventually surpassing a critical level  $\tilde{\beta}_0$  where task concentration in the labor-abundant foreign country becomes immune to local deviation. Given that  $nx = n^*x^*$  and  $w_0/w_0^* > 1$ , this level of  $\beta$  is defined by  $\tilde{\beta}_0 t(0) = (w_0/w_0^*) 2^\theta$ ; see (26). As  $\beta$  falls marginally below  $\tilde{\beta}_0$ , concentration of tasks  $i$  close to zero starts to set in. Part of the foreign production work force now works for managers in the home economy, while the opposite is not true for production workers in the home economy. Through scale economies in task performance and due to additional demand for foreign labor the wage rate for foreign production workers, relative to home production workers, starts to rise. However, for  $\beta$  lower than, but sufficiently close to  $\tilde{\beta}_0$  the wage inequality  $w/w^* > 1$  will be upheld.

To see whether an incipient task concentration in the foreign economy is the only possibility, we need to check possibilities of deviation. From the local deviation condition (26) we see that  $I > I^*$  for  $w > w^*$  and vice versa, given that  $nx = n^*x^*$ , as assumed. Looking at global deviation, condition (29), together with  $nx = n^*x^*$ , implies that deviating from concentration of task  $i$  in the home economy yields a positive expected profit if

$$\beta t(i) (w - w^*) > -(w - w^*) \quad (30)$$

Obviously, if  $w > w^*$ , then global deviation is profitable for the entire range of tasks. Conversely, for  $w < w^*$ , no global deviation from concentration at home is profitable for any task. Formally, with  $nx = n^*x^*$  the right-hand side of equation (29) reduces to  $-1$ , and therefore no solution exists for  $J \in ]0, 1[$ . This implies, that the global deviation condition always leads to concentration in the low-wage country for the whole set of tasks. Together with the local deviation conditions above, this means that for  $w > w^*$  concentration of all tasks  $i \leq I^*$  in the foreign economy is the only feasible equilibrium. This proves part (a) of the proposition, although we still have to determine the threshold level for the endowment difference.

Without loss of generality, we now assume that  $z(i) = 1$ , meaning that all tasks are equally important in the production process of any final good. Defining  $\tau(I) := \beta \int_0^I t(i) di$ , a *one-way-offshoring* equilibrium with  $w > w^*$  and task concentration in the labor-abundant foreign economy is described by the conditions

$$L = (1 - I^*)(nx)^{1-\theta} \quad (31)$$

$$L^* = (1 - I^*)(n^*x^*)^{1-\theta} + (nx + n^*x^*)^{1-\theta} [I^* + \tau(I^*)] \quad (32)$$

$$\beta t(I^*) = \frac{w}{w^*} 2^\theta \quad (33)$$

plus the conditions for final goods market clearing and full employment of managers in either country; see section 3 above. The first two lines state the two labor market equilibrium conditions, whereas the third line implicitly determines the cut-off value  $I^*$ , which separates tasks where concentration in the production labor abundant country is immune to local deviation ( $i < I^*$ ) from the rest. The second term in the foreign labor market equilibrium captures demand for foreign production labor that derives from tasks performed in a concentrated way in the foreign economy.

Exploiting  $nx = n^*x^*$ , these equations may equivalently be expressed as:

$$\frac{L^*}{L} = 1 + \frac{\tilde{I}^*(w/w^*, \beta) + \tau[\tilde{I}^*(w/w^*, \beta)]}{1 - \tilde{I}^*(w/w^*, \beta)} 2^{1-\theta} \quad (34)$$

where  $\tilde{I}^*(w/w^*, \beta) := t^{-1}[(w/w^*)(2^\theta/\beta)]$  is the solution to (33), expressed as a function of the relative production wage and the cost of offshoring. Obviously, this function is well

defined only for values  $\tilde{I}^*(\cdot) \in [0, 1]$ .<sup>15</sup> Note that  $\tilde{I}^*(\cdot)$  is increasing in  $w/w^*$  and decreasing in  $\beta$ . The right hand side of (34) gives demand for foreign production labor, relative to domestic production labor. A higher relative wage of home production labor increases  $\tilde{I}^*(\cdot)$ , the extensive margin of one-way offshoring, with concentration of tasks  $i \leq \tilde{I}^*(\cdot)$  in the foreign economy, thus increasing relative demand for foreign production labor.

Any value of  $\beta < \tilde{\beta}_0$  determines a certain measure of one-way task trade through the offshoring condition (33) above. This measure then also determines a certain amount of foreign production labor used for tasks concentrated there, inclusive of labor required due to offshoring cost,  $\tau(\cdot)$ . This is found in the second term on the right-hand side of (34), expressed relative to demand for home production labor which, by construction of our argument, is demand for non-concentrated (local) tasks only, always assuming equal country size.

In order to determine the threshold level  $\Lambda$  of the above proposition, it proves useful to introduce the notion of a country's *virtual production labor supply*. This is defined as the country's total labor endowment minus the labor employed in performing tasks towards production under the other country's headquarters.<sup>16</sup> An equilibrium of type (a) arises if virtual labor supply with foreign task concentration up to  $I^* = \tilde{I}^*(1, \beta)$  does not leave enough virtual labor supply to meet demand by the foreign country's own headquarters (managers). This is another way of saying that  $L^*/L > \Lambda$  where

$$\Lambda := 1 + \frac{\tilde{I}^*(1, \beta) + \tau \left[ \tilde{I}^*(1, \beta) \right]}{1 - \tilde{I}^*(1, \beta)} 2^{1-\theta} \quad (35)$$

is the relative demand that is induced by one-way task trade up to the local deviation threshold  $I^*$  with equalized production wages.<sup>17</sup> In other words, if there is foreign concentration of tasks all the way up to  $\tilde{I}^*(1, \tilde{\beta}_0)$ , foreign virtual production labor supply exceeds demand from the foreign country's own headquarters (or managers) at the wage  $w = w^*$ . Labor market

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<sup>15</sup>It is impossible to derive a closed form solution for the equilibrium cut-off value  $I^*$ , but nor is it necessary to do so for a proof of the above proposition.

<sup>16</sup>It is straightforward to show that for  $\tilde{I}^*(\cdot)$  the foreign economy's virtual labor supply is equal to  $(n^*x^*)^{1-\theta} \left[ 1 - \tilde{I}^*(\cdot)(1 - 2^{-\theta}) \right]$ .

<sup>17</sup>It is impossible to derive a closed form solution for the equilibrium cut-off value  $I^*$ , but nor is it necessary to do so for a proof of the above proposition.

equilibrium in both countries therefore requires lower relative foreign wage rate to induce more offshoring and thereby reduce the virtual labor supply. As we have demonstrated above, with this wage inequality and with  $nx = n^*x^*$  no domestic task concentration would ever be immune against global deviation, hence the pattern of task trade is unique, and it is one-way. This completes part (a) of the proposition.

Next, consider part (b) where  $L^*/L = \Lambda$ . In this borderline case, the task trade pattern is still unique, although with wage equalization,  $w^* = w$ . There is only one equilibrium pattern of task trade involving one-way offshoring and concentration in the foreign country of all tasks  $i \in [0, I^*(1, \beta)]$ . This reduces virtual foreign labor to an extent that supports an equilibrium with equal wages.

Finally, in a case where  $M^*/M < L^*/L < \Lambda$  there exists more than one offshoring pattern that leads to wage equalization, since there is an infinite number of ways in which the interval  $[0, \tilde{I}^*(1, \beta)]$  may be split into subintervals where the foreign and the home economy, respectively, host concentration of task performance. In this sense, the pattern of task concentration is indeterminate.<sup>18</sup> Notice that once wage equalization is achieved none of the countries has a factor cost advantage for task performance, whence  $I = I^*$ . This completes the proof of the proposition.

The only remaining case that we have not considered up to this point is the limiting case where endowment proportions are equal. This brings us back to Grossman & Rossi-Hansberg (2010) who assume countries of equal endowment proportions but varying size. They show that there is a lower range of size differences where there is an equilibrium with wage equalization. But this equilibrium is unstable, surrounded by two stable equilibria with a unique concentration of some tasks in one of the two countries. This holds not true for our limiting case where the difference in endowment proportions vanishes. The reason is that the stable equilibria in Grossman & Rossi-Hansberg (2010) involve different aggregate output levels in the two countries. The country with a higher wage has a higher aggregate output

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<sup>18</sup>This indeterminacy bears a close resemblance to the well-known “Melvin indeterminacy” which arises in factor price equalization equilibria for Heckscher-Ohlin models where the number of goods exceeds the number of factors.

and vice versa. Since we only concentrate on equilibria with an identical aggregate output in the two countries, our single equilibrium with equalized wages must be stable.

### 4.3 What does offshoring do to managerial incomes?

From the equilibrium condition of the managerial salary  $s = cx/f(\sigma - 1)$  we can derive total income earned by home managers as

$$sM = \frac{1}{\sigma - 1} \left( wL + \frac{nx}{(nx + n^*x^*)^\theta} w^*T(\mathcal{F}) - \frac{n^*x^*}{(nx + n^*x^*)^\theta} wT(\mathcal{H}) \right). \quad (36)$$

Note that production and offshoring volumes are all determined endogenously. However, this expression still yields interesting insights into the distributional mechanisms between the two types of labor. Compared to the no-offshoring case in equation (9), home managers find their income increased, if there is a substantial number of domestic tasks offshored to the foreign economy, whereas their income is reduced by offshoring of foreign tasks to the home economy. This is very intuitive since concentration of production in a country means that fewer domestic workers perform manufacturing tasks for domestic managers and output per manager declines. Combining equation (36) with a corresponding equation for  $s^*M^*$ , we obtain

$$sM + s^*M^* = \frac{1}{\sigma - 1} (wL + w^*L^*). \quad (37)$$

It should be noticed that the above equations do not rely on equal country size; they allow for arbitrary asymmetries in both size and endowment proportions. We summarize these results in the following proposition.

**Proposition 4** (Offshoring and income distribution). *a) If countries are sufficiently asymmetric in their relative endowments, leading to an equilibrium with one-way task trade and persisting wage gaps for production labor, then managers in the country that hosts tasks performed also for the other economy are less well off, relative to production workers, than in an equilibrium without task trade. The opposite is true for the other country. b) In the presence of offshoring, the distribution between managers and workers in the aggregate of the two countries is the same as the one that is obtained for each country individually in an equilibrium*

where offshoring is ruled out.

Part (a) of this proposition follows from equation (36) and a corresponding equation for  $s^*M^*$ , whereby one-way trade of the type discussed above, i.e., with task concentration in the foreign economy, implies  $T(\mathcal{H}) = 0$ . The global invariance result in part (b) follows directly from equation (37).

## 5 Simulation Results

There are two reasons for using simulation methods in this context. First, as pointed out by Grossman & Rossi-Hansberg (2010b), the equilibrium depends on integrals over the set of tasks concentrated in each economy or performed in both countries, whereby these sets themselves are functions of the parameters in question. Furthermore, the external nature of the economies of scale might give rise to multiple equilibria, which further reduces the scope for analytical tractability. An additional benefit of the numerical simulation is that it allows us to identify likely orders of magnitude and to highlight non-monotonic outcomes regarding the offshoring pattern and wage payments. Importantly, numerical methods allow us to look at cases where countries differ both, in size and relative endowments. We choose parameter values so as to ensure comparability with Grossman & Rossi-Hansberg (2010b). Thus, the offshoring cost schedule is assumed to be linear, with  $t(i) = i + 1$ , and the external scale economy is assumed to take the form  $[X(i)]^\theta$ , with  $\theta = 0.8$ . Moreover, we assume  $f = 1$  and  $\sigma = 2$ . Grossman & Rossi-Hansberg (2010b) demonstrate that the choice of  $\sigma = 2$  implies that the symmetric case involves offshoring in both directions whenever there is offshoring at all. As we show in section 3 this choice has the additional advantage of yielding equal remuneration for managers and workers in the symmetric case whenever there is no offshoring.

We analyze inequality in two dimensions: Inequality *between* countries, measured by income per capita; and inequality *within* countries measured by the managerial wage premium. For each of these dimensions we differentiate between two cases: First, we look at the *symmetric case* where relative endowments are the same in both countries. We follow Grossman & Rossi-Hansberg (2010b) in assuming  $M/L = M^*/L^* = 1$ , with a world endowment equal

to  $M + M^* = 2$  and  $L + L^* = 2$ , and in looking at cases where the home economy is larger, i.e.,  $M = L > M^* = L^*$ . This case corresponds to the analysis of US offshoring vis-a-vis other developed countries. Secondly, we analyze an asymmetric case, where we assume the home economy to be abundantly endowed with managers, meaning  $M/L > M^*/L^*$  with  $M = L$ ,  $M^*$  remaining constant, and  $L^*$  increasing to increase asymmetry, which corresponds to US offshoring to developing countries. As discussed at length in the preceding section, we sharpen our focus on *relative endowment asymmetry* by shutting down the country size channel through the assumption  $nx = n^*x^*$ .

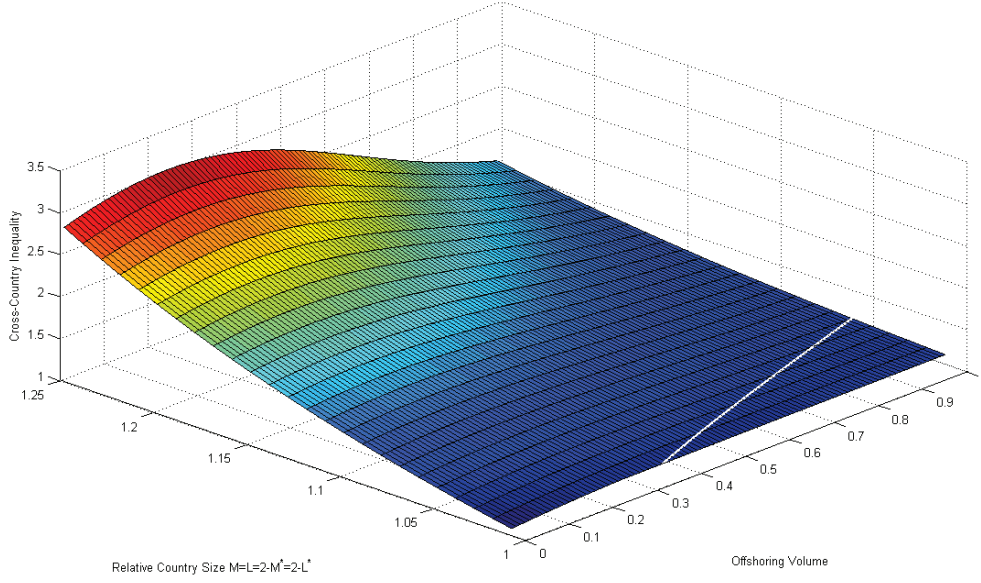
## 5.1 Cross-country Inequality

Remember that we measure inequality between the two countries by the ratio of incomes per head, as defined in (10). Remember also that we have chosen our numéraire such that  $w^* = 1$ . Hence, for the symmetric case with  $M/L = M^*/L^* = 1$ , our measure  $R$  simplifies to

$$R = \frac{s + w}{s^* + 1} \quad (38)$$

We first turn to the symmetric case, corresponding to offshoring between developed countries. Figure 3 depicts international inequality for varying degrees of size advantage as well as varying amounts of offshoring. Looking at alternative offshoring volumes seems natural, given the focus of the policy debate. Note that different volumes of offshoring implicitly reflect different values of  $\beta$ , which measures the costliness of trade in tasks.

The figure clearly indicates that the economies of scale work to the benefit of the large country. This effect is largest for medium levels of offshoring, meaning that the smaller (poorer) country suffers from initial steps of integration, but gains from additional offshoring once integration has come far enough. The intuition for this non-monotonicity is as follows. For low levels of offshoring, the home country benefits more from the first tasks moved to the other country, since tasks with low task-specific offshoring costs  $t(i)$  are concentrated in the small country, while tasks with higher offshoring costs are concentrated in the large country. Moreover, the number of tasks concentrated in the large country is higher. Hence, the large country has to spend less on transport costs and production-labor is more productive there



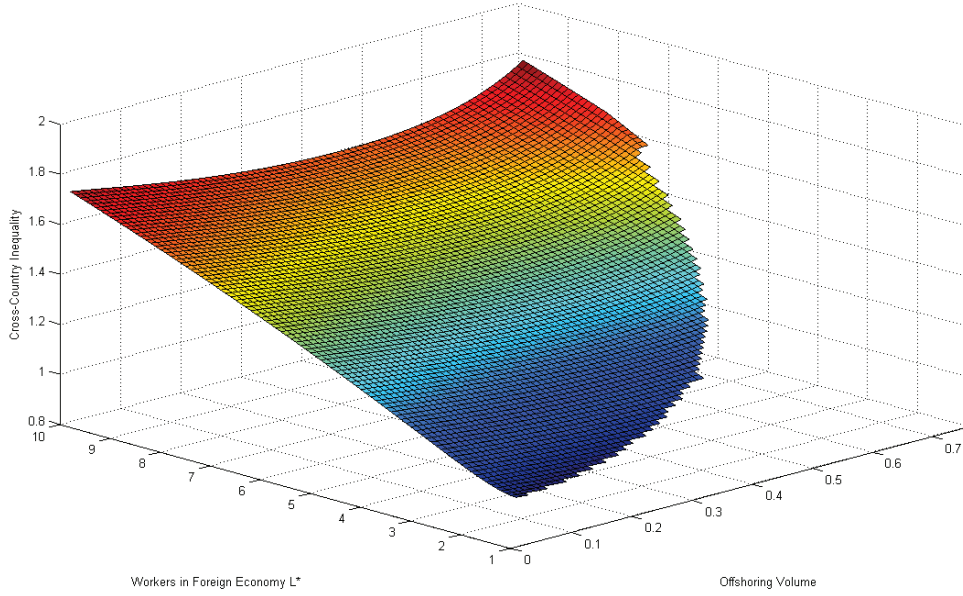
**Figure 3.** Symmetric Case: Cross-country inequality  
Independent Variables:  $M = L = 2 - M^* = 2 - L^*$  and  $VOL = \mathcal{H} + \mathcal{F}$   
 $\sigma = 2, \theta = 0.8, f = 1$

due to the scale effect. However, for high levels of offshoring, a further decrease in the cost of offshoring  $\beta$  brings more benefits to the small country. The reason is that small-country producers save more on transport costs for infra-marginal tasks, given the very same offshoring pattern outlined above.

We must, however, mention a small caveat. Imagine both countries to be of relatively similar size and globalization to be very advanced, meaning a high volume of offshoring. This case, which corresponds to parameter values to the south-west of the white line, implies the possibility of multiple equilibria and the larger country may end up with a lower aggregate output level, thus having a lower average production wage. We generally restrict our figures to depicting only the equilibrium in which the larger country produces a higher aggregate output and has a higher production wage.

Next, we look at the asymmetric case where the home country has a relatively larger supply of managers. This puts it at a disadvantage for hosting concentrated tasks. The case is depicted in figure 2 which focuses on relative endowments that are asymmetric enough to yield a unique one-way offshoring pattern. When the first tasks are concentrated in the country which is abundant in production workers, it is the workers there who benefit from





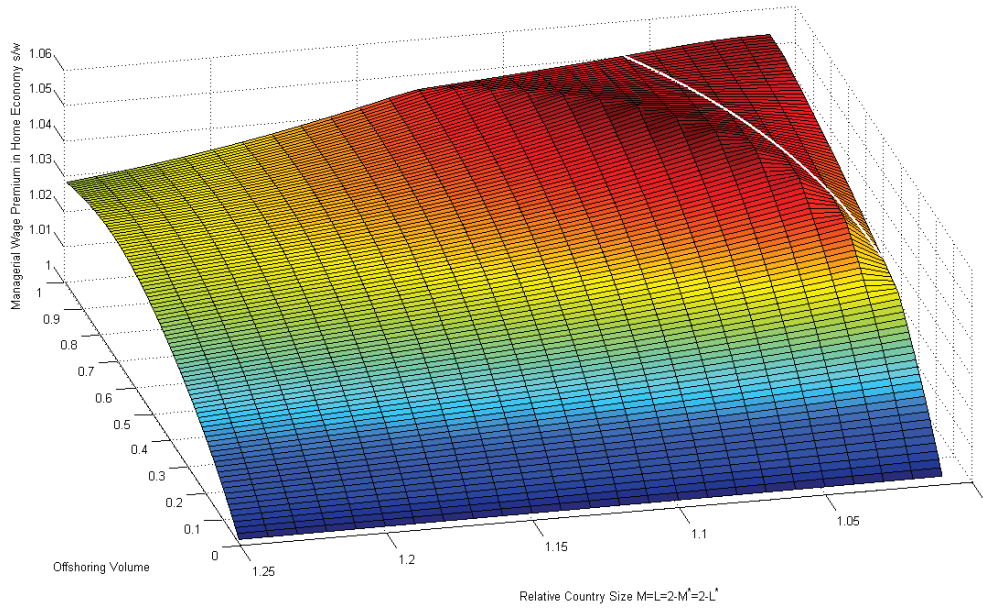
**Figure 4.** Asymmetric Case: Cross-country inequality  
Independent Variables:  $L^*$  and  $VOL = \mathcal{F}$   
 $\sigma = 2, \theta = 0.8, f = 1$

an increase in productivity and wages. This means that cross-country inequality is reduced. However, this pattern is reversed by a fall in  $\beta$  which induces more offshoring. Decreasing offshoring costs for infra-marginal tasks only work to the benefit of the manager-abundant country, so that with more and more specialization its workers can achieve an ever higher wage rate.

## 5.2 Within-country inequality

In this section we investigate the effect of country size and endowment ratios on managerial wage premia in the two countries. We report results for the home economy, assumed to be relatively large in the symmetric case and manager-abundant in the asymmetric case, attributes that characterize the US and therefore should yields an explanation for the empirically observed pattern outlined in section 2.

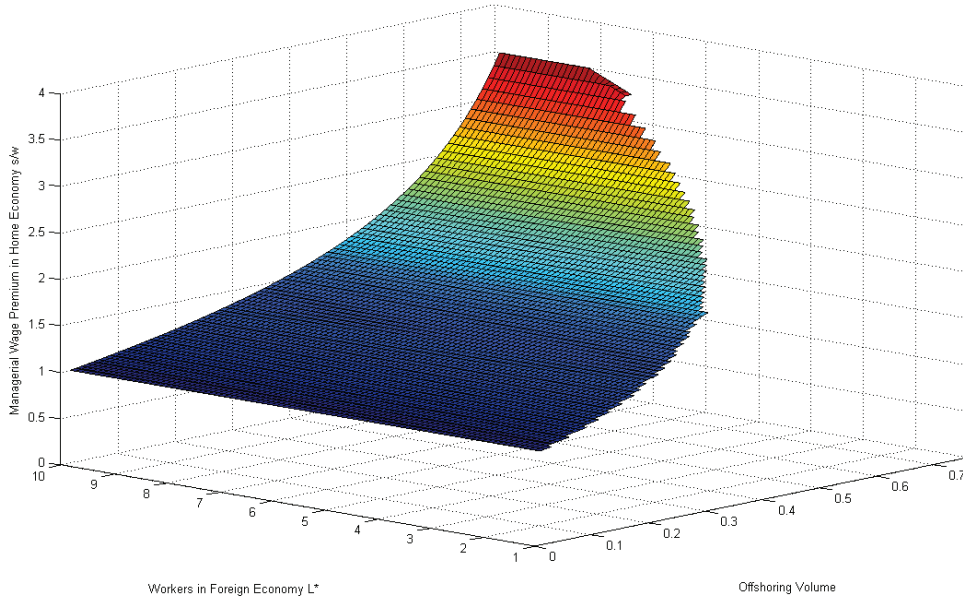
Regarding offshoring between two developed economies we observe that higher levels of offshoring drive up the managerial premium. The effect is smaller for highly unequal endowments. The intuition is that managers' salaries move proportionally with output per unit



**Figure 5.** Symmetric Case: Within-country inequality  
Independent Variables:  $M = L = 2 - M^* = 2 - L^*$  and  $VOL = \mathcal{H} + \mathcal{F}$   
 $\sigma = 2, \theta = 0.8, f = 1$

of fixed manager input, which is an increasing function of the *total* volume of offshoring. Production workers benefit as well, but only from the increased productivity in tasks concentrated *domestically*, which implies an increase in the managerial wage premium. Clearly, if the home country is larger, a larger share of total offshoring is concentrated there so that workers benefit almost as much as managers, and the increase in the managerial wage premium is less pronounced. This implies that, keeping aggregate offshoring constant, a more disparate endowment of labor between the two countries reduces the managerial premium in the large country. Intuitively, this effect is negligible for very small volumes of offshoring. Complete specialization entails the highest managerial wage premium only for medium values of relative country size, at about  $M = L = 1.15$ . For more unequal endowments, the maximum manager premium occurs with an offshoring volume of about 0.75, while for more equal endowments it depends heavily on the exact level of country size. As above, in figure 5 the parameter combinations for which a second equilibrium with higher wages in the small country might occur is separated, to the north-east, by a white line.

In the asymmetric case we can identify a very simple pattern of the income distribution in the manager-abundant country. A rising level of offshoring drives up the managerial wage



**Figure 6.** Asymmetric Case: Within-country inequality  
Independent Variables:  $L^*$  and  $VOL = \mathcal{F}$   
 $\sigma = 2, \theta = 0.8, f = 1$

premium, since home managers benefit from the increased productivity of their firms due to the offshoring possibility and thus receive higher salaries. Production workers in the manager-abundant country, on the other hand, do not benefit since no tasks are concentrated there. Interestingly, the skill premium remains constant for changes in the degree of asymmetry. Even though the endowment change only occurs in the foreign country, one could have thought that the world factor endowment should matter for the internal income distribution through the channel of offshoring. Comparing the symmetric with the asymmetric case, we see that offshoring tasks to a production-labor-abundant economy has a substantially larger effect than offshoring to another developed country. setup. Moving from no offshoring to a high level of offshoring, holding endowments fixed, can increase the managerial premium by a factor of around 3.5. In the latter case, however, moving from no offshoring to a substantial amount of offshoring only increases the premium by a factor of 1.05. This is very much in line with the notion we obtained from the empirical stylized facts in section 2 and confirms our view that our model is at least partially adequate to contribute to predictions of trends in the income distribution.

## 6 Conclusion

In this paper, we have argued that wage and inequality effects of trade should be addressed by focusing on the distinction between managerial and production workers. For a large part, managerial labor is a fixed input in production, while production work serves as a variable input. A key tenet of our analysis is that this asymmetry importantly shapes the determination of managerial salaries and production wages. A second fundamental assumption underlying our analysis is that production-labor often benefits from local spill-over effects related to narrowly defined tasks along complex value added chains, and that modern technology of communication and transport increasingly makes such tasks tradable. This creates a rationale for concentrating performance of single tasks in single countries, using countries' endowments with production workers, and to exchange the performance of such tasks across firms with headquarters located in different countries, depending on their endowment with managerial labor. This is an instance of trade based on "Marshallian" economies of scale.

We have used a 2-country model of task trade recently developed by Grossman & Rossi-Hansberg (2010b), in order to address inequality both within and between countries. Our analysis has focused on the role of country size and relative endowments with managerial and production workers, respectively, on the managerial wage premium as well as on income per capita in one country relative to the other. We have also compared these effects in a world with trade only in differentiated final goods, as against a world where there is trade in tasks governed by varying degrees of trade costs. We have first presented a number of analytical results. For instance, in a world without trade in tasks, we can neatly identify three different channels through which country endowments affect international inequality: There is a terms of trade effect, but also a productivity effect of countries becoming larger. In addition, there is a composition effect if endowments change in an asymmetric fashion.

Trade in tasks between symmetric countries is mostly two-way in nature, with small and large countries concentrating on different subsets of tasks. We have shown that task trade between asymmetric countries is one-way in nature, with non-equalization of production wages, provided that the two countries' relative endowment with production workers and managers are sufficiently asymmetric. This is reminiscent of the factor price equalization familiar from

standard endowment-based trade models. In non-wage-equalization equilibria, the production worker-abundant economy exports task performance against imports of differentiated final goods, and it has a lower production wage than the manager-abundant economy. Moreover, concentration of tasks in a given country always works against managerial wages in that country.

We have complemented these analytical results by numerical simulations. An interesting non-monotonicity arises for international inequality between differently sized countries that are symmetrically endowed with managers and workers. Starting out from low levels of offshoring, a reduction in the cost of task trade tends to generate gains mainly for the large country, while the opposite is true once these cost fall below a certain threshold value. A similar non-monotonicity arises in the asymmetric case, where for low levels of offshoring it is the country with more production workers that reaps the bulk of globalization gains, while manager-abundant economies benefit once globalization has gone sufficiently far.

An interesting result regarding orders of magnitude relates to how the managerial wage premium is affected by offshoring. If offshoring takes place in a “north-north” fashion, i.e., between countries with symmetric endowments of managers and workers, then a jump from very low to very high levels of offshoring, measured as the percentage of tasks concentrated in a single country, has a moderate positive effect on the wage premium, in the vicinity of 5 percent. It is, however, much more severely affected if this same change takes place for task trade between countries with asymmetric factor endowments, where the managerial wage premium increases by as much as 250 percent. Of course, these are numbers pertaining to a highly stylized model and should not, therefore, be taken literally. Overall, however, our analysis clearly demonstrates that task trade among similar and asymmetric countries is likely to have differential wage effects for managers and workers. An observation that is also confirmed by looking at empirical data for the US but has so far not received sufficient attention in the literature.

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